Railway Shop Up-to-Date

D·VAN·NOSTRAND COMPANY

Railway Shop Up To Date

A Reference Book of Up to Date American Railway Shop Practice

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Preface

This book goes forth as a record of what is found to exist as the best in railroad shop practice, design, construction and equipment. The editor has striven earnestly and long to compile all the available data valuable to the railroad official seeking information, whether it be for the purpose of building a new shop to meet modern and future conditions, or increasing the efficiency of an existing plant.

It was not originally intended to make this book so broad and comprehensive; but there was found to be such a vast quantity of related data and information on the subject, that it was deemed advisable to extend its scope to its present proportions.

All material has been condensed as much as possible without sacrificing necessary details or impairing the lucidity of any descriptions, so that each kind of shop or particular kind of practice followed, may be clearly understood and comprehended.

The value of such a compilation as this depends largely upon the proper arrangement of facts in their natural and logical sequence so that the effects and results of the evolutions continually in progress, in the up to date railway shop, are readily arrived at by the reader. We have based our statements upon and drawn our conclusions from conditions as we have found them and have not theorized upon ideal conditions.

We want this work to stand for exactly what its name implies. There are so many good shops, each apparently the best under the peculiar governing conditions and each new shop to be built hereafter will be subject to its own governing conditions, not possible to predict here, that it would be manifestly the sheerest folly to lay down a rigid policy or standard to be followed. We give what are found to be facts and governing conditions, but we know that there are new questions yet to be raised and unknown quantities in shop problems to be determined before any given problem can be solved.

It is necessary to go from the known to the unknown in this as in other lines of progress and we have attempted to supply information to help as far as we may. There is no doubt but that there will be found here one or more illustrations which will approximately fit the conditions to be met in building a new plant or modernizing an old one. While it is unlikely that an attempt would be made to plan one shop as an identical counterpart of another, each shop illustrated or described contains some features worthy of being emulated. Our aim has been attained if we have shown clearly the various types of modern railway shops.

We wish to express our appreciation of the kindly assistance rendered by the railroad officials with whom we have come in contact during the course of this work. It has been a pleasure indeed to note the willingness to assist and the interest evidenced in our undertaking. We only hope that our readers will find as much interest and pleasure in these pages as we have found in the associations formed in gathering the information for

RAILWAY SHOP UP TO DATE.

M. H. H.

Railway Shop Up To Date

Chapter I

INTRODUCTORY

A STUDY of American railway shops of to-day reflects the fact that each railroad contemplating the construction of a new shop or preparing plans to remodel an old one, will find it necessary to work out its own destiny according to its own requirements and peculiar governing conditions. Present railroad shops embody many features worthy of being emulated and in many instances there are a number of details in the shop of one railroad which may be used to advantage in the shop of another. However, an attempt to plan a shop under the mere specification that it shall provide for a given number of locomotives, without a thorough investigation and study of all governing conditions, would hardly result in success. The same may be said of an attempt to lay out and construct one shop as an identical counterpart of another on a foreign road, for the reason that governing conditions would hardly be alike and these conditions would necessarily modify the shop design.

The preparation of plans for a new shop is universally preceded by a comprehensive study of the most successful shops in operation—both old and new. However, the progress of shop construction has not adhered to such lines that a precedent can be established or any rules formulated by which shops can be prepared to meet all conditions.

Comparative data regarding the equipment and output of different shops is apt to be misleading on account of the difference in demand upon the shops of various systems consequent upon conditions affecting locomotive repairs. The character of traffic, grade, curvature, water supply, type and size of locomotives, etc., varies for each locality and affects the demands upon the shop. Each shop therefore is designed and equipped according to the dictates of local surrounding conditions and influenced by the personal preference of those supervising the design.

It may be said that the general layout of a shop is not always representative of an arrangement considered the most satisfactory for the work to be accomplished, but rather the most practical under the circumstances governing at the time the shop was built.

Its location is dependent upon the convenience provided for the accommodation of the system, or portion of the system, which it serves; convenience with respect to centers of supply of labor and material and advantages with respect to cost of land, buildings, taxes, etc.

Plans have been influenced by shape and size of available land, by location of property with relation to direction of main line, by provision for construction of new shops or remodeling of old, by character and quantity of work to be done, whether for manufacture as well as repair, and whether for maintenance of cars, locomotives or both, by the demand to be made on the shop by departments other than the mechanical and by prevalent ideas of economy.

In earlier shops the use of the transfer table was the principal factor in determining the most practical lay out in providing communication among the buildings. The introduction of the powerful overhead traveling crane, capable of lifting the heaviest locomotive, is shown to have modified the arrangement of buildings. This is especially noticeable in the locomotive department, though the variation is evident in repair and building plants as a whole. In the small plants built to meet the demand of railway equipment in its early stages of development, the effort was to locate buildings containing machinery so that power could be delivered by line shafts driven from one engine and it was thought that the rope drive would facilitate such an arrangement. Later developments include the delivery of steam from one boiler house to two or more engines located at different points about the plant for driving line shafts. It is now generally conceded that the distribution of electrical power from one central plant provides the most satisfactory method of power transmission and permits the most flexible arrangements of buildings and equipment. Practically all recent designs of railroad shops include a power house centrally located—or nearly so—and containing all apparatus for power and light, and frequently the principal heating apparatus. Many of the older shops have been extended and electrical apparatus installed liberally.

It may be said then that the introduction of electrical apparatus and traveling cranes, together with the use of air driven small tools and appliances and heavier machine tools with high speed steel, have been the prominent features in the evolution of the railway shop to meet the demand of the constantly growing motive power and rolling equipment.

The railroads of the country are found to have shops varying in degree of development. Some of them were built about forty years ago for the repairs of about twenty-five engines and they are still in operation. The fact that most of the large roads of to-day represent the

growth and absorption of the small roads of the past, is largely responsible for the "back number" shops found at division points of so many systems which in a general sense are considered up to date. Some railroad companies, noticeably the New York Central and the Baltimore & Ohio, are providing small repair plants, standard to their respective systems, for light repairs and remote roundhouses and these are found to be of material assistance in relieving the principal shops.

Railroad managements are waking up to the necessity of good terminal facilities for maintaining running repairs on the heavier equipment of to-day and for quickly turning the power in minimum time consistent with its condition upon arrival at the terminal. This is reflected particularly by the terminal plants at Elkhart, on the L. S. & M. S. Ry. and at East Altoona on the Pennsylvania.

The tendency in recent years has been to build a principal or main shop at some central point on a system where the greatest number of locomotives will be accessible for repairs and at which the freight traffic centers. Such a point is not usually found to be the geographical center, but rather the business center of the system.

There is evidence of but little improvement in the way of new shops at division points and the tendency seems to be to concentrate the heavy repairs at the main shops and maintain the light and running repairs at the outside points.

This would seem to be conceded by the following from the report of the committee on shop layouts at the 1905 convention of the American Railway Master Mechanics' Association:

"No matter how large and complete the main shop may be, the outlying points can advantageously and profitably use a moderate tool equipment for taking care of running and light accidental repairs, leaving heavy repairs and manufacturing to be done at the main shops. With such an equipment and organization, we believe that relatively small shops are undesirable, expensive and unprofitable, and that the larger, completely equipped main shops will handle the repairs in the most satisfactory manner."

Granting then that the railroad main shops have received the most marked attention in improvement and provision for modern facilities, it is natural to turn to these as representative of the trend of shop progress. For this reason the diagrams and tables here presented are compiled principally from data descriptive of the main shops, including those most recently constructed and the most prominent among the older shops.

Shop kinks and devices for saving time and labor have been developed by individuals to meet the requirements of conditions surrounding their work. Such kinks often have been found worthy of imitation, sometimes with greater or less modification to meet conditions in other surroundings. New shops have felt the need of jigs, templates and methods, and have progressed but slowly until such devices and systems have been installed. The value of such items in the old shops was hardly appreciated until their want was felt in putting new shops into commission. Hence, items of older shop practice, where found efficient, are given prominent notice and in all cases governing conditions are considered in reaching conclusions.

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Chapter II

LAYOUT

GROUPING OF BUILDINGS.

FROM a careful comparison of shop layouts and an observation of the trend of progress represented by successive years, it is apparent that the aim in preparing plans has been to so arrange the buildings and several departments as to group those provided for the same class of work, locating those serving two or more groups on sites equally accessible to the several groups served and providing throughout for inter-communication among the buildings so as to facilitate the movement of material with the least amount of unproductive travel.

The transfer table is prominent as the vehicle for communication and distribution at older and smaller shop plants and the buildings at such plants are seen to be largely grouped around one or more transfer table pits as principal avenues or thoroughfares. The same tendency to group buildings around a main thoroughfare of movement and distribution is apparent in the layout plans of recently constructed large shops. In them, however, the transfer table is not the controlling feature, the seeming tendency being to minimize its use in order to remove the obstruction offered by the pit, to economize the space which it covers and to reduce the number of doors which would be required in the side of a building served by a table.

In the large modern plants the transfer table is found very generally to serve the passenger car department buildings, operated between the paint and repair shops, and the tendency, becoming more pronounced, is to group the other principal buildings about a long narrow space or thoroughfare served by a yard traveling crane. Such a layout provides for the location of the passenger car department at a remote part of the plant where the transfer table pit will offer no impediment to general yard traffic. In this arrangement of buildings and accessories of large modern plants lies a marked similarity to the grouping of buildings in the smaller shops about the transfer table pit as a main thoroughfare, for example at the smaller shops planned about 1898.

GOVERNING CONDITIONS.

Size, shape and topography of available land together with the condition of providing new shops throughout or remodeling old shops, have influenced the arrangement of buildings and layout of some shop plants as a whole. As a result there are shops which are representative, not of the most desirable design, but of the most practical arrangement under peculiar governing conditions. This fact accounts for some features which otherwise would be open to criticism and which include disadvantages, duly realized and reckoned with by the local officials when planning the shops. Such examples, fortunately, have emphasized the necessity of a freer scope for those preparing shop plans and there is now more noticeable effort to procure land to suit the shop.

Further argument for a large tract of land in allowing free scope for a shop layout is the necessity of providing for future extensions, for yard room in which to store material for the several departments, for sufficient distance between buildings as a prevention against fire risks, as well as for open roadways to facilitate movements of wagons and fire fighting equipment.

The criterion by which a shop design is tested is its facility of operation and its capacity for returning equipment to service in minimum time. Results obtained in the operation of certain new shops have served to demonstrate more clearly to recent designers that utility is of greater importance than seeming economy in first cost. Such false economy has often proved very expensive by necessitating changes and alterations after shops were put into commission.

COMPACTNESS PROVIDED BY SINGLE TRANSFER TABLE.

About the period of 1898 to 1903 several shops were built in which there is a marked similarity in the layout and arrangement of buildings and accessories. In fact there is a greater resemblance among the general lines along which these shops were plannd than is noticeable among shops built at any other period, until very recently. These are the shops of the Chicago Great Western at Oelwein, Ia.; Colorado & Southern at Denver, Col.; Chicago, Burlington & Quincy at Hannibal, Mo.; Wisconsin Central at Fond du Lac; Fort Worth & Denver City at Childress, Tex.; Oregon Short Line at Pocatello, Idaho, and Southern Pacific at East Los Angeles, Cal. Diagrams of several of these shop layouts are shown and by reference to them it will be seen that the principal buildings are grouped around a single transfer table. At these plants the locomotive erecting shops contain nine, ten and fifteen pits and are built to maintain repairs of from 150 to about 200 locomotives. For shops of this capacity and such size that a single transfer table can be used to advantage, it seems to be conceded generally that such a type is the most satisfactory. For the main shop of a comparatively small road or for a division shop of a large road, then, these shops establish a precedent for compactness and convenience.

At shop plants of larger capacity the size of buildings and size and shape of available land has usually restricted the advantages of the single transfer table and these conditions have been met by grouping some departments about two or more transfer tables and by modifying the track arrangements of the locomotive and car shops.

ACCESS TO SHOPS.

This brings the question to a point concerning the

transverse or longitudinal arrangement of erecting or repair stalls. Due consideration of these arrangements appears in later chapters referring particularly to the individual buildings. Their features for the present are restricted to such discussion as affects the layout.

LOCOMOTIVE SHOP.

Some older and small plants provided entrance to cross erecting shops by a fan tail track approach radiating from the roundhouse turn table or a shop lead and others provided a similar approach for a longitudinal shop. In earlier years a large transverse shop required a transfer table and the longitudinal shop required as many lead tracks as there are tracks in the erecting shop.

The introduction of the large traveling crane, capable of lifting the heaviest of locomotives, has provided advantageous features for both transverse and longitudinal shops. It has brought about improved facilities by which locomotives are delivered to and from the shop and such features naturally affect the layout of the shop plant in, so far as it is influenced by the locomotive shop as one of the factors.

The inference to be drawn from the design and arrangement of a number of the most recently constructed shops is that the transfer table is no longer generally considered a necessary adjunct to the transverse locomotive shop and by dispensing with this, the space previously occupied by the transfer table pit is available for yard room. Dispensing with the transfer table reduces the number of doors necessary in one side of the building, and removes an impediment to general yard traffic. Where such an arrangement prevails, engines enter and leave the shop over one track, either at one end or at the center of the building. If the building is parallel with the general line of yard tracks, engines must be delivered over a turntable, convenient to the entering lead, unless the roundhouse is so situated that the roundhouse turn table is available. If the building is arranged transversly with the general line of yard tracks, no turntable is necessary.

Longitudinal shops are usually arranged parallel with the general line of yard tracks and locomotives enter and leave the shop on the central of three working tracks. No turntable or transfer table is necessary with such an arrangement as a locomotive is transferred from the entering track to the working spaces of the other tracks, by the traveling cranes. At the Angus shops of the Canadian Pacific Ry. locomotives usually enter the shop on the center track, though each shop track is connected with the yard line, where they are stripped, and are delivered by the traveling crane to the working spaces. They leave the shop from the side track nearer the wall, where they are fired up within the shop as there is no roundhouse at this repair plant.

FREIGHT CAR SHOP.

Recent general practice indicates the more common use of longitudinal tracks in freight car repair and building shops, though two railroad companies use roundhouses in such capacity. The instances are the Pennsylvania Railroad at Altoona and Columbus and the Norfolk & Western Railroad at Roanoke. Access to the longitudinal freight car erecting shop is usually by a track approach at one or both ends of the main building, though at a few railroad shops built previously to 1900 and at a number of freight car manufacturing plants, the plan provides for a yard approach at one end of the main building and a transfer table at the other.

PASSENGER CAR SHOPS.

Both old and new shops, with a few exceptions, adhere to the common practice of providing transverse repair and paint shops served by a transfer table, for the passenger car department. Exceptions are the old shops of the Norfolk & Western at Roanoke, the Pennsylvania at Altoona and the more recently built (1902) shops of the Mexican Central at Aguas Calientes, Mex., and the Pittsburg & Lake Erie at McKees Rocks.

FLEXIBILITY PROVIDED BY ELECTRICAL POWER.

The effect upon shop layouts produced by the introduction of electrical transmission of power, is to permit greater flexibility in the location of buildings with respect to the requirements of departments which they serve and with regard to convenience of the shop plant as a whole. It is now possible for practically all apparatus for the generation of power to be confined to a single power plant located as nearly as possible at the center of the shop plant and in practically all recently constructed shops this arrangement is found to obtain. Individual buildings are located as requirements demand and the direction of the line shaft is no longer a controlling feature.

STOREHOUSE.

The location of the storehouse is a very essential factor. Its position practically determines the base of supplies. As a store house at a main shop usually supplies the system, this building requires a convenient arrangement of tracks to provide for the receipt and delivery of material. The storehouse is also the principal point of supply for the shop plant and as such its place is one easy of access to all departments. The most improved storehouse, together with its supply and store platform, usually constitutes a long narrow structure and the department includes scrap platforms, sheds and bins. It is frequently placed between the locomotive and car departments, however, its most convenient location is dependent upon the facilities provided for distribution of material. It is evident, therefore, that much depends on the location of the storehouse, from the standpoint of the efficiency of the individual shop plant at which it is located as well as convenient facilities for receiving and distributing material for the line.

At those shops concentrating the buildings about a transfer table the storehouse is located usually at one end of the transfer table pit in order that the table may be used as a vehicle for distribution. The storehouse platform of the Colorado & Southern at Denver has a section lowered to the level of the transfer table to facilitate handling material in this manner.

It is significant to note the similarity between this loca-

tion of the storehouse with regard to the transfer table pit as a thoroughfare of distribution and inter-communication and the location of the storehouse in shop plants having a crane covered thoroughfare or midway, as the principal avenue. This may be seen by reference to the diagrams illustrating the layouts of the Canadian Pacific at Montreal and the Big Four at Indianapolis. It is noticeable that a portion of the storehouse platform is served by the yard crane and that the crane so serves the principal buildings as to establish efficient communication between the storehouse and the several departments, and among the principal buildings.

ROUNDHOUSE.

It is substantially an established practice to locate the roundhouse near the locomotive, or machine and erecting shop and connect it with the same by a standard track. At Elizabethport, Central Railroad of New Jersey, the transfer table pit is between the roundhouse and the locomotive shop. This is unusual and is probably accounted for by the arrangement of buildings to suit the shape of available land and to place the roundhouse at a point convenient to the main line and to branch lines which diverge at this point.

There is a growing tendency to provide a small shop equipped to maintain roundhouse repairs independent of the main shop and thus establish light repair facilities close to the work, and at the same time relieve the locomotive machine shop of jobs which are constantly coming up and which necessarily are of such nature that it is difficult to prepare for them in advance. This usually includes machine and blacksmith shop facilities to handle running repairs only, for it is considered cheaper to send an engine requiring accidental repair work to the adjacent main or division shop, rather than attempt to maintain a large machine shop at the roundhouse for such emergency repairs as are apt to overtax their ordinary running repair facilities.

At the same time it is still common to find a few machine tools in a roundhouse at a main shop for machine work at night, and at other times that the shop may be shut down, yet the machine shop is depended upon for the heavier machine work required for running repairs.

At Collinwood, on the Lake Shore & Michigan Southern, there is a small independent machine and blacksmith shop for running repairs exclusively. This roundhouse is located some distance from the locomotive shop and hardly may be considered as a portion of the locomotive and car shop plant. It is fairer to consider this roundhouse in the light of an independent small plant.

The same may be said of the Elkhart roundhouse of the same road. At each of these roundhouses, there is a main or division shop sufficiently close to send driving wheels dropped in the roundhouse and requiring journals to be turned.

The East Altoona roundhouse of the Pennsylvania Railroad is located at a greater distance from the repair shop and is equipped to be more independent than either of those just mentioned, and driving wheel work is done at the roundhouse machine shop.

The details of this feature of roundhouse equipment are considered at greater length in a later chapter and are here presented as concerning the effect in preparing plans for a shop layout.

By thus providing for roundhouse equipment, the roundhouse can be conveniently situated at a point isolated from the shop and yet more convenient for either the freight yard, passenger station or both. The roundhouse being then isolated from the shop yard, the entire available land may be used as best suited to the requirements of the shop. The conditions governing the location of certain buildings to accommodate the requirements of the roundhouse are thus eliminated and a freer scope is allowed in locating the buildings to the best advantage of the several shop departments.

BLACKSMITH SHOP.

At shops for both locomotives and cars, there is usually one blacksmith shop to serve both departments. This shop, therefore, is usually so located as to be easy of access to both departments. Frequently its ground plan is L shaped, one section being devoted to the work of each department, each wing paralleling the department which it serves.

FOUNDRY.

The iron foundry is usually located at such a point that castings can be delivered conveniently to the storehouse for line shipments and direct to the several shops where castings are machined or assembled. At the Angus shops of the Canadian Pacific, there are two foundries. The gray iron foundry is situated on the midway in order that the output may be handled by the yard crane and the wheel foundry is located near the freight car department so that wheels may be delivered directly across the wheel storage yard to the truck shop where wheels and axles are mounted and assembled.

PLANING MILL.

Planing mills are commonly so placed that the finished lumber may follow the shortest path of productive movement from the lumber yard and through the various machines to the freight car erecting shop. Also in arranging the layout, it is customary to so locate the planing mill with reference to the power house that shavings from the various machines may be delivered readily to the boiler room by air ducts. This to some extent determines the location of the power house, in order to provide for use of shavings for fuel of one or more boilers. Except for this controlling feature the natural location of the power house is at the center of the plant.

LUMBER YARD.

Lumber yards, dry kilns, etc., are naturally located within easy access to the planing mill and effective transfer of material requires good track facilities throughout the lumber yard and connecting with the mill.

SCRAP DEPARTMENT.

Older shops made but little provision for storing, classifying, separating and disposing of scrap material. In view of the capital represented by scrap and the large amount which has been found to accumulate at principal shops, from both road and shops, the newer shops have

been made to include a scrap department as an important feature of the shop layout. This is usually in connection with the stores department. The use of traveling hoists located over several tracks in one portion of the scrap department is becoming more noticeable. Such hoists are found very useful in unloading cars of scrap that come in from the line and in sorting heavy material.

AUXILIARY DEPARTMENTS.

The smaller departments, such as brass foundries, bolt and nut shops, tin shops, upholstering shops, paint shops, etc., are located as best suited to the requirements of larger departments which they serve and they are considered more in detail in connection with the buildings in which they are usually located, instead of in connection with the general layout.

DISTRIBUTION OF MATERIAL.

Naturally the prime motive of the shop is to make repairs with maximum expediency and to return equipment to service in minimum time. Each building stands much in the same relation to the entire shop plan as the several component parts of a machine bear to the completed mechanism. This signifies the requirement of effective inter-communication among buildings. Distribution of material rapidly, economically and with least unproductive movement, then, is the keynote in the general arrangement of buildings, facilities and equipment.

Beginning with new supplies this includes the delivery of material from the store house to the several departments.

The peculiar character of repair work requires a certain amount of retroactive movement, for instance the movement of a locomotive frame to and from the blacksmith shop and the movement of other parts to and from the repair gangs, etc. Blacksmith shops and foundries, therefore, are so located as to provide for effective movement to and from the storehouse, locomotive erecting shop, car department shops, etc.

The arrangement and equipment of individual buildings are provided to suit their immediate needs and requirements of departments which they serve. Also the buildings are so located as to secure most effective operation, to provide for the movement of hand trucks of the industrial system and to include thoroughfares of inter-communication.

CLASSIFICATION.

Basing the classification of large shops for repairing both locomotives and cars upon the leading characteristics of the layout and the grouping of the principal departments, Mr. Walter G. Berg, chief engineer of the Lehigh Valley Railroad, who has given the subject of shop design much careful study, has classified American shop systems as follows:

A.—Complete transfer table layout.

(a) All departments combined along one transfer table.

(b) The various departments grouped along separate transfer tables.

B.—Combination of transfer table and longitudinal layout.

(a) Longitudinal freight car shop; all other departments, transfer tables.

(b) Longitudinal locomotive erecting shop, longitudinal freight car shop, and transfer table passenger car shop.

C.—Combination of a transfer table and a cross locomotive erecting shop with traversing crane for lifting engines over each other.

(a) Cross locomotive erecting shop with crane for lifting engines over each other, otherwise transfer tables for all other departments.

(b) Cross locomotive erecting shop with crane for lifting engines over each other, passenger car shop with transfer table, and longitudinal freight car shop.

D.—Layouts without transfer tables.

(a) All longitudinal layout.

(b) Cross locomotive erecting shop with crane for lifting engines over each other, otherwise longitudinal layout.

This classification is claimed to cover practically all railway shop systems of the country. The several combinations existing in any one shop have resulted from governing conditions and the personal preference of officials having the deciding vote.

The system of serving all departments by one transfer table seems to be commonly preferred for shops having a capacity of about fifteen locomotive stalls or less, to serve as the principal shop of a small road or as a division shop of a large road. It was said before that there is a greater similarity among the shops of this type than among any others until very recently. While the various systems may be included in Mr. Berg's classification, there is a marked dissimilarity among the general features of the ground plan layout of shops built about the same time and during successive years. There is now a growing tendency, evident from the general layout of recently built shops, to concentrate the departments about one crane served thoroughfare as an avenue of inter-communication and serving much in this capacity as did the transfer table in the shop system served by a single table. In such systems the groups are arranged around the avenue of inter-communication and each department is arranged within itself as requirements demand. The plants at Angus, on the Canadian Pacific, and Indianapolis on the Big Four, are arranged much on the same general principles, though the former includes a longitudinal locomotive shop and the latter a transverse locomotive shop. Each has a longitudinal freight car erecting shop and at each the passenger car repair and paint shops are arranged transversely and served by a common transfer table. The storehouse and locomotive shop are at one end of the midway and opposite to each other. The freight car repair shop and yard are at the farther end of the midway and the blacksmith shop, foundry, car machine shop, truck shop, etc., are grouped along the midway where they can be served by the yard crane. The

only transfer table in either of these plants serves the car department.

In this connection it is interesting to note that the Collinwood shops of the Lake Shore & Michigan Southern, built in 1902, are soon to be provided with a crane to serve a storage yard extending across the plant and occupying a position between two rows of the principal buildings. This area is between the locomotive shop, storehouse, power plant and passenger car department on one side and the brass foundry, bolt, blacksmith and car machine shops, mill building and new freight car repair shop (now under construction) on the other side. Provision for the future extension of all buildings is in two directions away from this area and the crane served yard will provide a thoroughfare among the principal buildings and a storage space controlled by the several departments.

In the locomotive shop the erecting pits are arranged transversely and this shop is not served by a transfer table. In the new freight car shop the repair tracks will be arranged longitudinally and the passenger car department is provided for by three transverse buildings served by two transfer tables. New cabooses are built in one of these buildings. This department occupies a corner of the plant in order that the transfer tables will offer no impediment to general yard traffic.

From a strictly up to date standpoint, the best practice for large shops is found to include a longitudinally or transversely arranged locomotive shop (according to the personal tastes of officials having the deciding vote) equipped with traveling cranes for transferring locomotives from the entering track to the erecting pit; a freight car erecting shop with longitudinal tracks, and two buildings served by a transfer table for the passenger car department, one located on each side of the pit, used for coach repair shop and paint shop respectively. All of these are commonly long narrow buildings and the problem resolves itself largely into the matter of best locating these buildings to suit local governing conditions. The tendency has been to do away with the transfer table, except in connection with the passenger car department, especially in colder climates, and the passenger car department is usually located as remotely as possible in order that the transfer table pit will offer least impediment to general yard traffic.

The storehouse and minor shop buildings are located with relation to these buildings as best suited to the department or departments which they serve.

In the comparatively new plants the leading feature is the provision for inter-communication and compactness to contribute to delivery of material at the same time making due allowance for storage space to serve the principal departments and sufficient distance between buildings to guard against fire risks. It would, therefore, seem that the older shops represent more of a mongrel growth and a present day classification would group modern shops as follows:

1.—All department buildings combined along one transfer table pit as a principal avenue of distribution and inter-communication.

2.—Principal buildings arranged along crane served runway as avenue of distribution and inter-communication with transfer table serving passenger car department only.

3.—Arrangement of yards without transfer tables in which the principal buildings are provided with longitudinal tracks, or in which there is a cross locomotive shop with other buildings arranged with longitudinal tracks.

4.—Mongrel growth to provide for increased capacity according to available facilities.

EVOLUTION OF OLD SHOPS.

The older shops, while including many up to date features, hardly represent the best general layouts or ground plan arrangements. Though these shops were considered ideal in every particular when built, improved facilities have been introduced which the older construction and arrangement of buildings prohibit unless the plant should be entirely rebuilt. In some instances this has been done either by securing new land at a distant point and erecting a new plant or by acquiring adjacent land and supplanting one or more departments at a time. In making such improvements, as the new buildings provided for transfer of departments, the space thus vacated has been utilized by other departments.

Where enlargements have been made to introduce modern facilities in an old plant, the new buildings are not always situated so as to produce the most economical movement of material.

While not intended as a criticism of the older shops, this is mentioned to illustrate how the latest shop plans show more compactness in the location of buildings and greater facilities for distribution of material among the various shops.

INDIVIDUAL EXAMPLES OF SHOP LAYOUTS.

In order to portray more clearly the characteristic features of railroad shop layouts, a number of the older shops are shown as well as several of the more modern, from which conclusions may be drawn as to the best practice. For this purpose the following are good examples:

I. C. R. R.—BURNSIDE.

At the Burnside shops of the Illinois Central Railroad the original plans provided for a blacksmith shop and boiler shop in the same building, separated by a fire wall, and located across the transfer table pit from the locomotive erecting and machine shop. The latter shop contains 24 transverse pits, served by a crane of 100 tons capacity, and the original ground layout provided for a future possible extension of this building to embrace 40 or 50 pits. This building originally included the principal car wheel work and wheels and axles were stored in the space beyond the locomotive shop.

During recent years the machine tool capacity has been largely increased by the construction of two long narrow galleries, or balconies, in the machine bay and by the removal of the car wheel department to a new shop which

has been built in addition to the passenger car repair shop. In order to provide greater facility in both blacksmith and boiler work, a new boiler shop has been built and the present locomotive department of the blacksmith shop is to be extended to include the old boiler shop.

The new boiler shop is located at a point beyond the old blacksmith shop and boiler shop and the pits are arranged transversely, served by an overhead traveling crane and includes the use of a transfer table. These improvements represent the provision of facilities for increasing work in the boiler, blacksmith and machine departments without increasing the capacity of the locomotive shop as a storage plant and will provide for a larger and more economical output with the same number of repair pits.

The boiler shop contains 24 erecting pits, or stalls, and this provision is made to meet the demand of the next 15 or 20 years, which accounts for the construction of a boiler shop of almost the same length as the locomotive erecting shop.

A new roundhouse has been added to the original plan, thus doubling the facility for roundhouse work.

A. T. & S. F.—TOPEKA.

The Topeka shops of the Atchison, Topeka & Santa Fe, are an example of the extension of the original plant, embracing car and locomotive shops, to provide a new locomotive department, modern in every particular, as well as an addition to the freight car repair department. The new shop buildings were erected on acquired land adjacent to the old shop plant and the area previously occupied by the locomotive shop has been converted to meet the requirements of auxiliary departments. The old locomotive shop was on the side of the main line tracks to Atchison, opposite to the present site.

The conditions peculiar to this plant are such that yard tracks enter from one end only and transverse traffic among the several buildings and departments is dependent upon cross tracks equipped with small turntables for push cars, at the intersections of longitudinal and cross tracks. While the location of the storehouse is convenient for line shipments in being near the main tracks, its position would appear out of the way so far as convenient distribution of material throughout the shop plant is concerned. The passenger coach shop and present paint shop is served by two transfer tables and there are no transfer tables in the other departments. The use of two transfer tables in the passenger car department is unusual and the second table is probably provided for delivery between the planing mill, storage yard and truck shop and the coach shop.

Arguments have been presented in favor of serving a passenger car shop with more than one transfer table, where the shop tracks are of such length as to provide a standing capacity of two or more cars on each track; but in view of the impediment to general yard traffic on account of the transfer table pit and the inconvenience provided by the accumulation of snow, the general tendency has been to dispense with transfer tables wherever possible.

The planing mill at Topeka is conveniently located with regard to the passenger and freight departments. The freight car repair shed is the most liberal provision of its kind for this class of work of which information is at hand. Practically the entire freight repair yard is under roof. The principal buildings included in the additions providing for the locomotive department are the locomotive, blacksmith and wheel shops, powerhouse and isolated lavatory.

The locomotive shop occupies a position at one extremity of the plant, though later development included in the additional freight car department will extend the shop yard beyond the site of this building. The locomotive erecting pits are arranged longitudinally and the building includes the erecting, machine, boiler and tank departments. The central pit track extends the full length of the building and engines are stripped and finished on this track. In order that no congestion might result from this practice, a turntable is located east of the building and adjacent to the boiler department and tanks enter the shop over this table. To further facilitate this plan and the crane service, transverse stall tracks are provided for tender frame and tank work.

Additions are now being made at Topeka which include a new passenger car paint shop, and a new freight car plant which will be considered as an extension of the present freight car repair facilities.

The new paint shop will be situated 50 feet south of the present paint shop. It will be 320 feet long by 110 feet wide and will be served by a transfer table operating at the south side of the new building.

The additions to the freight car department will be in a group of new buildings situated on a tract of land about 1,300 feet east of the locomotive shop. This will include a freight car repair shed, 208 feet 6 inches by 900 feet, which, it will be observed, is larger than the present repair shed of the original plant; a freight car planing mill, 75 feet by 350 feet; a dry kiln, 50 feet by 60 feet; freight car structural steel shop, 80 feet by 200 feet; wheel shop, 60 feet by 100 feet, and scrap bins constructed of old sills. Adjacent to the freight car planing mill is a boiler and engine room, 44 feet by 50 feet and 36 feet by 50 feet respectively. On each side of the dry kiln is a small 6 foot transfer table to facilitate distribution from the dry kiln to the freight car planing mill.

C. & N. W.—CHICAGO.

At the Kinzie street, Chicago, shop of the Chicago & Northwestern Railway, all departments were originally grouped around several transfer tables before this plant was extended in 1901. Since that time a new longitudinal freight car repair shop has been built and the transfer table serving the locomotive shop has been extended to serve a newly constructed boiler shop which is modern in its equipment and includes the service of overhead traveling cranes. The erecting and machine shop is not served by overhead traveling cranes and locomotives entering the shop for all classes of repairs are stripped and

unwheeled in the boiler shop where crane service is available and, when necessary, boilers are removed from frames in the boiler shop. The skeleton and machinery are then transferred to the erecting shop by the transfer table and wheels are handled by a traveling jib crane.

P. & L. E.—MC KEES ROCKS.

The Pittsburg & Lake Erie shops at McKees Rocks, represent successive improvements for the locomotive and later for the car department and illustrate additions to provide for gradual improvements. The layout of this plant is limited by the shape and size of available land, being included in a peculiarly shaped narrow strip between the main tracks and the side of a hill.

The present caboose repair and tank shop and the coach repair shop are in old buildings once occupied by the locomotive shop. A few years ago a new locomotive shop was built which includes 20 transverse pits served by an overhead traveling crane capable of lifting an engine over those standing on the pits and a crane of small capacity for handling lighter parts, operating on runways at different heights. In this plant the boiler shop is in a separate building arranged at right angles to the locomotive shop. The blacksmith shop and storehouse are parallel to the boiler shop and this group of buildings represents a convenient arrangement for efficient service where it is preferred to place the boiler department in an isolated building. On the opposite side of the erecting and machine shop are two roundhouses and the power house. Both roundhouses are connected with the erecting shop and engines entering the shop for repairs are delivered over the roundhouse turntable. This arrangement obviates the necessity of a turntable to serve the erecting shop, and the whole layout represents a very compact grouping of buildings. One roundhouse is being used temporarily as a steel car repair shop.

The passenger car paint shop, while in a modern and convenient building, is peculiarly located on account of the lack of space and is some distance from the other car shops. A modern freight car shop has recently been completed. This shop is the best equipped, especially for work on steel cars, of which information is at hand. The shop arrangement includes longitudinal tracks. One bay is to be devoted entirely to repairs of steel cars and provision is made to include space for furnaces and other apparatus in handling parts of such cars.

B. R. & P.—DU BOIS.

The locomotive shops of the Buffalo, Rochester & Pittsburg at Du Bois, are comparatively new and modern shops and represent up to date practice. The locomotive shop includes the longitudinal arrangement of tracks with the erecting bay in the center and machine bay on each side. The shop originally included the boiler department at one end and the shop as then built was expected to turn out about 12 locomotives per month. Its present output averages 24 to 26 per month.

In order to secure this increased capacity a new boiler shop has been constructed so that the space heretofore occupied by machine tools for boiler work has been supplanted by machine tools for locomotive work and the standing capacity on the pits has been similarly increased.

The boiler shop is in a new, modern building located at a distance of 145 feet from one end of the locomotive shop and is arranged transversely with the latter. The stall tracks are transverse and are served by a crane of 30 tons capacity. The shop is served by a 45-foot transfer table which provides communication between any stall of the boiler shop and the longitudinal tracks of the erecting and machine shop, as well as with an entering or lead track.

The blacksmith shop is north of the erecting and machine shop with a distance of 40 feet between the two buildings. The roundhouse is located south of the erecting and machine shop with a distance of 275 feet from this shop to the center of the turntable. A straight transverse track across the erecting and machine shop, connects with the roundhouse on one side and with the blacksmith shop on the other. This track does not enter the blacksmith shop, but intersects a longitudinal track through the shop. The power house is north of the erecting and machine shop and east of the blacksmith shop. The storehouse is north of the erecting and machine shop. It is entirely surrounded by a platform at the height of an ordinary box car floor and is well served by track connections. The oil house is south of the storehouse and west of the roundhouse and is well situated with relation to both.

It is interesting to compare the general ground plans of the B. R. & P. shops with that of the locomotive department of the P. & L. E., as representative of two shops with about the same capacity, in one of which the locomotive erecting pits are arranged transversely and served by overhead traveling cranes, and in the other the pits are arranged longitudinally and served by overhead traveling cranes. In both plants the buildings are closer together than is usually customary and would indicate that with present day structures and fire protection equipment, shop designers are justified in planning for greater compactness in the arrangement of buildings. At Du Bois the buildings are capable of extension to meet greater demands of the future, while at McKees Rocks there is no further available land for the extension of shop buildings.

C. P.—ANGUS.

As compared with shops previously built the ground plan, or general layout of the Angus shops of the Canadian Pacific Railway represents an innovation in the general arrangement of principal buildings to provide for the several departments. The principal governing features are the disposition of the only transfer table, namely, that serving the passenger car department at a remote point in the plant where the transfer table pit does not impede general yard traffic and the introduction of a crane served thoroughfare as the principal avenue of inter-communication. The use of a traveling crane in the yard was not original with the Angus shop plant, nor did the idea of grouping the buildings about one thoroughfare of inter-

communication originate with this shop layout. Other shops had used overhead traveling cranes to advantage in the yards and several shops, referred to in the early part of this chapter as being similar to each other with regard to certain principal points and constructed about 1899, represented an arrangement of grouping buildings along a single transfer table pit which serves as an avenue of inter-communication.

The Angus shop represents a layout using both features to advantage, but omitting the transfer table as the principal vehicle of distribution. The buildings are grouped around a principal thoroughfare and the crane provides a vehicle for transferring material. At the same time the ground space covered by the crane is available for material tracks and as a road for teams and instead of offering an impediment to general yard traffic as would the transfer table pit, it provides greater facility in this connection. The crane also offers greater convenience as a means of delivery than does a transfer table.

The buildings are at right angles to the midway and a system of standard gauge material tracks for both longitudinal and cross traffic among the buildings is connected with the tracks of the midway by 8 foot turntables at track intersections. The system of material tracks, while of standard gauge, is independent, in that the 8 foot turntables will offer no impediment to locomotive traffic. The plant is served by a system of through tracks connected with a belt line surrounding the yards for delivery of material in carload lots to the various storage spaces. All departments are provided with large storage spaces which are particularly essential in view of the shop being largely a manufacturing concern.

The minimum distance between the buildings is 75 feet which, while providing against fire, is arranged principally to provide for storage space and trackage room throughout the yard. The land on which the plant is situated is of such size and the buildings are so located as to provide for the increase of all buildings in large ratio. Such additions may be made without interfering with future yard traffic and without greatly increasing travel among departments.

Cross travel of material from the lumber yard to and from the mill is provided for by a small transfer table at each end of the mill. The pits are quite shallow and do not interfere with foot traffic in the vicinity of the mill building.

The passenger car shop is served by a transfer table which is located beyond the zone of general yard traffic in order that no impediment may be offered by the pit. The transfer table travels parallel with tracks provided for yard traffic and cars are delivered to and from the transfer table over a curve. In view of the unlimited ground for the location of buildings it would appear that these shops would have been more convenient had this transfer table pit been arranged transversely with the yard tracks.

In view of the large size of this shop plant it would appear to be extremely well arranged and while ample provision is made for storage, the arrangement of the buildings is at the same time quite compact.

The locomotive shop and general storehouse are at the south end of the midway and on opposite sides. The blacksmith shop, gray iron foundry, pattern shop, car machine shop, truck shop, car erecting shop and planing mill are also adjacent. The planing mill and freight car shop are on opposite sides of the midway and are in the same straight line to provide for economical movement of material direct from the lumber yard through the mill machinery and to the car erecting shop. The gray iron foundry is near the locomotive shop to provide for the delivery of heavier castings. The blacksmith shop is located to serve both the locomotive and car departments and car material from this shop passes in natural sequence through the car machine shop and truck shop on its way to the car erecting shop. The wheel foundry is located contiguous to the freight car department with wheel and axle storage yard between it and the truck shop so that this building too is a feeder to the freight car erecting shop.

The locomotive shop provides for erecting, machine, boiler and tank departments within a single building which also includes work on pilots, running boards and other wooden parts. The erecting pits are arranged longitudinally.

The freight car paint shop is practically a continuation of the erecting shop so that transferring a car from the erecting shop to the paint shop consists in merely moving the car forward as in advancing from one stage of construction to the next. The mill, erecting and paint shops are located in a straight line with the lumber yard and dry kiln contiguous to the mill, an arrangement which presents most desirable features for delivery of material and for productive movement.

C. C. C. & ST. L.—INDIANAPOLIS.

The Big Four shop at Indianapolis is also an entirely new plant throughout and in general layout reminds one of the Angus shop. The principal features differ somewhat and are arranged to suit the governing conditions and tastes of those responsible for the design. In this shop the principal buildings are grouped around a midway 75 feet wide served by a 10-ton crane. As was said with regard to the Angus shop, the transfer table serving the car department is placed in a remote location. However, the direction of the transfer table pit appears more desirable inasmuch as it is arranged transversely to the general line of yard tracks and delivery to the table is more direct.

All departments and all principal buildings are directly tributary to the midway and the layout is somewhat influenced by the fact that the shop yard is adjacent to a large double hump gravity freight yard. A general system of tracks parallel to the main line track serves all departments and is connected to the main line at both ends of the shop yard. Cross travel among the several departments is provided for by transverse standard gauge industrial tracks and 8 foot roller bearing turntables at track intersections. The erecting and machine shop is a modification of the locomotive shop at Sayre, on the Lehigh Valley, the erecting pits being arranged transversely in two rows with the machine space between

them. These pits are parallel with the shop tracks so that a turntable is not absolutely necessary in delivering locomotives to the shop. However, a turntable is introduced which serves to assist inter-communication between the boiler shop and tank shop and erecting and machine shop, which are in separate buildings.

The blacksmith shop is conveniently located to serve both the locomotive and car departments. The storehouse is located very near the center of the yard from which point it serves the several departments conveniently. The iron and brass foundry are at the extreme west end of the yard so that the transportation of raw material at this point does not impede general yard traffic. One side of the iron foundry is served by the yard crane and a platform, one side of which is partly under the yard crane, extends from the iron foundry to the storehouse. Raw material enters one end of the foundry and finished castings are delivered directly to their destination in the shop plant or delivered to the storehouse for storage and for line shipments. The pattern shop, although convenient to the iron foundry, is isolated from all other buildings for fire protection.

The freight car repair yard is adjacent to the main freight switching yard so that the switching of repaired and bad order cars will be reduced to a minimum. The freight car repair shop is practically at the center of the south edge of the repair yard. The freight car department is across the midway from the passenger car department at the east end of the yard with the planing mill located on the north side of the midway, and between the passenger and freight car buildings. Lumber is stored at the extreme east end of the yards away from all buildings and lumber passes in regular sequence through the dry kiln, dry lumber shed and mill directly to its destination without doubling its course.

The wheel shop is located just north of the storehouse and is so situated as to serve equally well the car department, the tank shop and a depressed track for shipment of wheels to outside points.

The power house is situated at the center of the north side of the midway where it is at the center of distribution when all requirements of power are considered, and is so located with relation to the mill building as to provide for delivery of shavings by an exhaust system to the boiler room. All buildings using power are within a radius of 1,000 feet.

Lavatories and closets are in general located inside of or adjacent to all buildings with proper enclosures and ventilations.

There is a minimum distance of 75 feet between buildings for fire protection and there is ample yard area tributary to each building for storage space. The location and arrangement of buildings is such as to provide for 50 per cent increase in all departments without interfering with future yard traffic and without greatly increasing the necessary travel among the departments.

The principles adopted in the general arrangement are not affected by the necessity of providing roundhouse equipment and facilities. There will be two 25 stall roundhouses at a point convenient to both the shops and terminal tracks of the eastbound and westbound yards.

L. & N.—SOUTH LOUISVILLE.

At the South Louisville locomotive and car shops provision for inter-communication is made by grouping the principal buildings tributary to two thoroughfares arranged at right angles with each other and assuming the form of an L. One of these avenues is a transfer table pit about 920 feet long and the transfer table serves the locomotive shop on one side, and the freight car erecting shop, planing mill, coach, paint and tender shops and storehouse on the other side of the pit. The other wing of the L is a storage yard, 1,000 feet long by 40 feet wide, for raw and semi-finished material and is served by an overhead, high speed, traveling crane of 10 tons capacity.

All departments are served by a system of standard gauge tracks which are tributary to a belt line encircling the entire shop plant. These tracks serve as the industrial system for the delivery of material among the buildings on hand cars and, inasmuch as delivery across the general line of tracks is provided for by the transfer table, there are no turntables in the track system, a feature which provides greater scope for general yard switching service throughout the plant.

The pits in the locomotive shop are arranged transversely and the boiler shop is included within one end of the locomotive shop. While engines entering the locomotive shop are commonly delivered over the transfer table, this shop is not entirely dependent upon the table as an engine may be delivered over a track entering the locomotive shop at about its center, and transferred by the traveling crane to any desired pit by lifting it over the others standing on the erecting floor. This arrangement presents an excellent provision against congestion, and while in general every day service the table is used only about five per cent of the time by the locomotive shop as against 95 per cent by the car department, either the crane or the transfer table may relieve the other in case of emergency, and it is hardly likely that both of them will be out of order at the same time.

The entire arrangement of buildings is for the economical movement of material, beginning with raw material in the storage yards and advancing to objective points near the center of the plant. All lumber enters at the south end of the yard and is distributed from the planing mill as required. Metal enters at the north end of the yard and the metal working shops are on that side of the plant, so that movement from storage yards to the individual shops will be over the shortest and most direct route. Similarly, the semi-finished product is delivered from one shop to the other, etc. Such progressive movement and delivery is particularly adaptable in that the shop plant is largely for manufacture and consequently there is much less retroactive movement than would obtain if the plant was devoted to repair work entirely.

The freight car repair shop and yard are accessible from the storage yard and the planing mill is in the

path between them and the lumber yard. The freight car erecting shop for new cars is on one side of the mill and the passenger car shops on the other and the transfer table provides communication among them.

The location of the general storehouse is such as to make it accessible to the transfer table pit, as an avenue of delivery, and near the belt line where switching facilities are available, thus serving the shop and the line to good advantage.

The power house is near the mill building to provide for delivery of shavings to the boiler room for use as fuel and considering the large amount of power required by the mill, as well as considering the general layout of the several shop buildings, the power house is not really far from the center of the plant as a whole.

Provision is made for extension of all buildings and such extensions will be made in directions away from the transfer table pit. A space has been retained for a new boiler shop so that by placing the boiler department in a new building, that portion of the locomotive shop now devoted to boiler work may be used for locomotive repairs and machine work, thus increasing the capacity of that shop.

In describing the transfer table it was explained that the locomotive shop is not entirely dependent upon the table, and in the event of accident to the transfer table, entrance to car and tank shops may be made by means of the yard tracks and all tracks in the buildings would be so accessible with the exception of two tracks in the coach shop.

C. R. R. OF N. J.—ELIZABETHPORT.

The Elizabethport plant of the Central Railroad of New Jersey presents an interesting example of a shop layout governed by the shape of available land, in which a transfer table serves both the locomotive and passenger car department and illustrating the effect of the location of the roundhouse as a prominent factor in the distribution of buildings. The available land, in this case, was in the form of a right angle triangle, two sides of the triangle being formed by the main line of the road and by a branch line. Another diverging branch line joins the main line at the same point, so that the most desirable location for the roundhouse was in the rectangular corner of the shop yard, near the juncture of the diverging lines. The oil house is naturally located near the roundhouse, and while it is generally considered desirable to arrange the oil house in connection with, or adjacent to the storehouse, it is, of course, natural to place the oil house near the roundhouse, where the location of store and round houses is such that the other practice cannot be followed. As the roundhouse is not equipped with an independent small shop for the maintenance of running repair work, it is essential that the locomotive shop should be near the roundhouse and communication between the two is provided by a straight track connected with the transfer table. While it is unusual to place a transfer table pit between these two shop buildings on account of the impediment which it offers to traffic, it is reported by the shop management that no difficulty is experienced on this account.

The passenger car repair and paint shops are grouped on opposite sides of the transfer table pit and the blacksmith shop occupies a position convenient to both the locomotive and car shops. The storehouse, also, is located to be of equal access from both the locomotive and car departments and is well provided with track connections. The power house occupies a position which will be at the center of the plant when contemplated freight car shops have been erected.

The arrangement of the buildings provides for ample extensions and tributary to each building is liberal storage space.

C. & E. I.—DANVILLE.

The arrangement of buildings in the locomotive department of the Danville shop plant of the Chicago & Eastern Illinois would indicate the application of a principle of making the other buildings tributary to the roundhouse. The oil house, storehouse, blacksmith shop, erecting and machine shop and boiler shop are all adjacent to the roundhouse and while they are laid out squarely and on straight lines, their grouping assumes much the form of an arc of a circle with the turntable as a center.

The erecting and machine and boiler shops are served by a common transfer table and are on the same side of the transfer table pit. A straight track passing between these two buildings connects the roundhouse turntable with the transfer table.

Plans for contemplated car shops to be embraced within the same general plant, provide for passenger coach and paint shops to be located across the transfer table pit from the erecting and boiler shops and to be served by the same table. A planing mill and freight repair yard are to be situated beyond the present power house and when these additions have been made, the power house will occupy a place practically at the center of power distribution.

While the arrangement of buildings is most compact, provision is made for the future extension of all departments.

C. R. I. & P.—SILVIS.

The Silvis shop of the Chicago, Rock Island & Pacific is another example of the locomotive shop being constructed and plans provided at the same time for the addition of a car department in the future. This shop is an instance wherein practically no restrictions were provided as to shape and arrangement of buildings. Taking the shop plant as a whole, and including the car department as it is contemplated, one of the governing elements is the elimination of the transfer table from all departments except for serving the passenger coach and paint shops.

The shop yard is adjacent to the main line and a general system of through tracks parallel to the main line serve all departments and is connected with the main

line at both ends of the yard. There are nine miles of track in the yard. Two tracks extend through the erecting shop and one through the blacksmith shop. The storehouse is served by two tracks at each side and the power house is served by one track to provide for coaling facilities. At the east end of the locomotive shop are tracks for the storage of wheels.

The roundhouse is located west of the locomotive shop where it will be convenient to both the shop and the yard terminal, and engines entering the shop are headed in the desired direction by the roundhouse turn table. The buildings constituting the plant are separated by a minimum distance of 50 feet and there is ample yard space. tributary to each building to provide necessary storage area. The principal buildings of the locomotive department are ranged near together and the buildings of the car department are conveniently grouped. The erecting, machine and boiler departments are in one building and the arrangement of erecting pits represents a rather novel feature. Locomotives enter the shop on a longitudinal track and are placed on erecting pits situated at an acute angle with the longitudinal track and representing what is known as the "herring bone" system.

The blacksmith shop is near the locomotive shop and one end of the building is used as a brass foundry. While not in a central position between the locomotive department and the proposed car department, the blacksmith shop is in a position which will be accessible to the latter when built. Its situation nearer the locomotive shop provides for immediate needs and material for car work is of such nature as to be more readily transferred than that which passes between the blacksmith and locomotive shops.

A scrap platform occupies a position east of the blacksmith shop and just north of the boiler department of the locomotive shop. The location of the storehouse is nearly central as regards the locomtive and car departments and a very interesting feature in connection with the storehouse is a large supply platform which is served by a crane of five tons capacity, having a span of 80 feet and traveling on a runway 400 feet long. This crane extends over one of the delivery tracks and over a part of the platform for its entire length. A delivery platform, 15 feet 8 inches wide, extends along each side of the building and at the west end is a platform 17 feet 8 inches wide, which extends to the refined oil house. The oil house is so situated as to be convenient to both the roundhouse and the storehouse.

The power house is at the north side of the locomotive department and will occupy a position nearly at the center of electrical distribution when the car department has been erected and when all classes of power are considered.

While the car department has not yet been constructed, the plans as now arranged provide for a passenger coach and paint shop served by a common transfer table, the pit to be arranged transversely with the general line of yard tracks. The freight car erecting shop will be east of the passenger coach shop at a distance of 230 feet. One end of this shop will include a car machine shop. The planing mill is located southeast of the freight car repair shop where it is in position to serve both the freight and passenger departments, but nearer to the freight car shop, in view of the larger percentage of material naturally delivered to the latter.

Lumber is stored at the extreme east end of the yard and its location with regard to the dry kiln, planing mill and covered shed for storage of dry lumber, is such that lumber works through the dry kiln, planing mill and covered shed directly to its final destination without doubling in its course.

Provision is made for future extension of all buildings in both the locomotive department, which is already in service, and in the car department, not yet constructed.

RAILWAY CAR SHOPS.

Prevailing practice indicates a tendency to group car and locomotive departments in one general plant and including a number of buildings used jointly by both departments. The only shops devoted entirely to car work and operated strictly by railroads, are those of the New York New Haven & Hartford at Readville, the Delaware Lackawanna & Western at Scranton, the Missouri Kansas & Texas at Sedalia and the Wabash at East Decatur. At the Kingsland shop of the Delaware Lackawanna & Western, while originally planned for a combination car and locomotive plant, the car department was in operation before construction work began on the buildings of the locomotive department.

N. Y. N. H. & H.—READVILLE.

The Readville shop is operated for the maintenance and repairs of both freight and passenger equipment. In preparing for this shop plant, a site was selected at a convenient point near Boston, between two branch lines, the available land providing for good track arrangement and facilities and offered no restrictions as to shape and size of buildings. The plant consists of the following principal buildings, passenger coach paint and erecting shop, freight car repair shop, mill building, storehouse, blacksmith, iron machinery, truck and cabinet shops, and piping, turning and buffing shop, power house, dry kiln and hardwood shed. The property provides ample room for shop approaches and while the plant is a large one, the buildings are arranged very compactly.

The minimum distance between buildings is 50 feet, while there are but few instances in which there is a maximum distance of over 100 feet. The general layout plan provides for an arrangement of buildings, material yards, working tracks, supply tracks, etc., by which material passes from its source through the various buildings, machinery and departments to its destination with productive movement and without doubling in its course. The arrangement of buildings, providing standing capacity for cars, in both passenger and freight departments, are representative of prevailing ideas in this connection.

The passenger car erecting shop contains 10 tracks

at 24-foot centers, each holding 3 cars, providing a total standing capacity of 30 cars. This building is 25 feet from the transfer table. The transfer table pit is 75 feet wide, and 100 feet east of the transfer table is the paint shop which has the same standing capacity as the erecting shop. There is a second story in the south end of each building providing for varnish rooms, upholstery shop and toilet rooms. The space provided between the paint shop and transfer table is used for stripping and scrubbing cars and for storing them while waiting to enter the shop.

The freight shop includes the longitudinal arrangement of tracks and contains 7 tracks at 20 foot centers, having a standing capacity of 60 cars. These two departments are arranged with reference to the mill building, lumber yard and other buildings serving these departments jointly, so as to provide for the movement of material in natural working sequence.

The capacity of the shop under ordinary circumstances is 180 passenger cars per month for all classes of repairs and 1,000 freight cars receiving general repairs. The shop was constructed to concentrate the heavy car work of the railroad system at one point.

The storehouse is located south of the passenger car department and 100 feet from the blacksmith and iron machinery shop. It is on the opposite side of the plant from the car shop. The storehouse, machine shop, oil house, truck shop and coal storage space of the power house are served by two parallel tracks, thus providing for wheel work, heavy parts, material for the storage department, etc., in a comparatively narrow territory while buildings for lighter work are placed and grouped conveniently.

Electrical distribution of power is used throughout and those buildings requiring power are grouped near together and within a short radius of the power house.

The lumber yard is in the western portion of the shop yards away from all buildings and its location is such, when taken in connection with the location of the hardwood shed, dry kiln, mill building and the other departments, that lumber follows a progressive movement without doubling in its course through these several departments to its final destination.

The passenger car department is very close to the several auxiliary shops and is connected with the mill by two through tracks. A space, or avenue, 100 feet wide, separates the tracks of the freight car department from the through track to the lumber yard so that both the freight shop and freight car repair shop tracks are located conveniently to the source of supply.

The hardwood shed is 300 feet by 50 feet and the dry kiln is 125 feet by 75 feet. These buildings are larger than is common to most car departments, but is necessitated by the amount of cabinet work done on sleeping cars, parlor cars, etc., and required by the demand of a rather large cabinet shop.

Yard traffic throughout the plant is provided for by a system of parallel tracks which connect with a loop encircling the plant and all tracks converge near the east end of the yards. Cross traffic is provided for only by the transfer table and by an avenue 100 feet wide extending transversely across the plant.

Freight repair facilities include a system of tracks evenly spaced and arranged on 20-foot centers, west of the freight shop, and a system of tracks similarly arranged east of the shop with a standing capacity of 500 cars. The tracks of both yards converge and are connected by leads at opposite ends of the plant.

D. L. & W.—SCRANTON.

The Keyser Valley shops of the Delaware, Lackawanna & Western, located at Scranton, are designed and operated for the construction and repair of freight car equipment. The road maintains about 29,000 freight cars and the principal work is concentrated at this point. The capacity of the shop is about 1,200 heavy repairs per month, the construction of about 400 new box cars with steel reinforced under-framing, in addition to light repairs of about 7,000 cars in adjoining repair yard, per month. Practically no passenger work is done here save for the construction of a few baggage and milk cars. While the plant contains no shop building especially equipped for the repair of all steel cars, a number of steel hopper cars have been repaired very successfully, on which the principal work has been done in the blacksmith shop.

The general ground plan layout includes no transfer table service and the buildings are arranged according to a longitudinal system of tracks, the stall tracks of the various buildings and light repair yard being approached by leads connecting with the yard system of transfer tracks. Track approach to the shop yard is from one end only and there is no belt line encircling the yard. The shop buildings are between the point of approach and the principal storage yard and all cars loaded with raw iron, lumber, etc., to be delivered to the yard must traverse the length of the shop yards and are delivered over tracks passing between the buildings and within the limits of the industrial track system.

The principal buildings are arranged along both sides of a wide thoroughfare, toward the south end of which the storehouse and office building is located. They are placed at such distances as to provide ample room for yard storage of material, to allow for extension of all buildings and to insure against fire risks, as well as to admit liberal daylight. They are arranged in such a manner as to provide for the progressive movement of material from the iron and lumber storage yard at the east end of the plant through the several shops and stages without doubling. Inter-communication among the shop buildings for the distribution of material is provided for by a narrow gauge industrial track system. At the intersections of industrial tracks are turn tables which permit of transverse as well as longitudinal traffic and all industrial tracks through the various buildings are tributary to the transverse tracks through the principal yard thoroughfare.

The plant includes the following principal buildings: Two freight car repair shops, with a capacity of 48 cars each, one being used for the construction of new equipment and the other for heavy freight car repairs. On the side of the main thoroughfare opposite to the car repair shops are the mill, blacksmith and machine shops, all of which are of comparatively easy access from the repair shops. The mill is on the same center line as the shop for heavy freight repairs. Near the mill is the lumber shed, with open sides, for the storage of finished lumber. The blacksmith and machine shops form the two wings of an L, this arrangement providing for quick and convenient movement of material from the blacksmith shop, through the various machines on its way to the car shops. Nearby is a storage space for wheels and axles, from which they pass through the machine shop to cars on a depressed track, and they are delivered either to the car erecting shop or to the line, as needed. Just outside of the blacksmith shop is an iron shed and beyond the blacksmith shop is a coal house for the storage of coal used in this shop. The coal house is served by a trestle to facilitate delivery and unloading.

The power house occupies a position next to the machine shop and adjacent to the principal thoroughfare. Its location is such that all buildings requiring power are within a convenient radius and considering the supply of air required for the freight car repair shop, oil house, light repair track, etc., its situation conforms with the character of the plant.

The storehouse is at the north end of the principal thoroughfare. On each side is a platform of convenient height to a car floor and to the rear is a storage platform, 200 feet by 75 feet. The basement, first floor and portion of the second floor are occupied by the stores department, while the offices of the master car builder and his staff, and a drawing room for the car department, occupy a portion of the second floor.

The oil house and paint shop annex occupy a long narrow building, 280 feet by 20 feet and the two are separated by a fire wall. This building is located at a distance of 120 feet from the paint shop and 118 feet from the car erecting shop.

The paint shop is west of the car repair shop and the car erecting shop and has no direct track connection with either. It has a standing capacity of 60 cars.

Directly in front of the storehouse and office building is the yard for light repairs, in which about 250 or 300 cars are repaired per day. This yard contains 8 tracks arranged on 20 foot centers and between every alternate pair of tracks is a narrow gauge track of the industrial system. In this yard one track is reserved for the repairs of steel cars.

For convenience in storage and delivery of material this yard contains a series of long narrow material sheds in which are kept bolts, nuts, finished lumber, sheathing, car doors, couplers, etc.

There are two scrap platforms, or docks, in the yards, one of which is near the blacksmith shop and the other near the light repair tracks. Both are equipped with air operated shears, and the various kinds of scrap are sorted into classified bins. The platforms are level with a car floor and industrial tracks traverse the length of each platform.

All lavatories are outside of the buildings. There are four of these located at various points of convenience, each 50 feet by 25 feet.

Lumber entering the mill from the lumber yard passes through doors at the end of the mill building, while lumber from the finished lumber shed passes through a side door conveniently located. From these entrances lumber follows paths of progressive movement through the various machines until finally loaded for delivery to the car erecting and machine shops. While much material is delivered from the mill on cars traveling over the industrial tracks, a great deal of it is transferred to the car building shop in box cars. Scrap pieces, shavings, etc., are loaded into special cars for delivery to the boiler room.

Raw iron for the blacksmith shop is stored nearby in order to facilitate quick delivery to the machines and hand forges. Progressive movement carries material through the machine shop, and onward to the car building shop or freight car repair shop.

WABASH—EAST DECATUR.

The East Decatur shops of the Wabash Railroad are located at a point convenient for serving the middle western district of the Wabash R. R. They are located on a tract of land containing 78 acres, which is well drained and which provides no limitation in the arrangement and layout of the buildings, tracks, etc.

On account of the mild climate and the almost complete absence of snow at Decatur, it is possible to repair freight cars out of doors during most of the year and for this reason no large provision is made for repairing freight cars under roof.

The plant has a sufficient capacity for 150 to 200 bad order cars per day and to build 12 to 15 new freight cars per day, as well as to give general repairs to from 15 to 20 passenger cars per month.

Repair tracks for bad order cars occupy the extreme southern portion of the yards. There are 4 repair tracks arranged in two groups of 2 tracks each, placed at 20-foot centers. Between each pair of repair tracks is a material distribution track and between the two groups are 3 material racks each 8 feet by 56 feet arranged at convenient intervals.

The main repair shop is 463 feet long and 188 feet wide and is intended chiefly for repairs of passenger cars. There are 4 repair tracks in this building arranged longitudinally and the principal buildings are located parallel with this shop and the freight car repair tracks. The buildings, therefore, are parallel with the general line of tracks. They are arranged compactly while providing for large future extensions, and the plant includes no transfer table. The buildings serving both

departments are located between the car shop and the freight car repair tracks.

The blacksmith and machine shop occupy one building, 294 feet by 80 feet which is located next to the bad order tracks. In line with this building is the power house, 60 feet by 108 feet, which is located quite close to the planing mill and directly south of it. This not only places the power house near to the building which will consume the greatest amount of power, but also provides for the delivery of shavings and other refuse from the planing mill. The planing mill is 238 feet long by 80 feet wide and contains two longitudinal tracks, one of which completely connects the two systems of track on the east and west side of the shop plant.

North of the blacksmith and machine shop is a long shed, 210 feet by 90 feet for iron, coal and coke. The store house is 464 feet by 40 feet and is situated between this shed and the car shop. This places the store house practically at the center of distribution.

The offices occupy a position in one end of this building and on the second floor. The oil and paint shop is at the opposite end of the building. North of the car shop is a long building, 40 feet wide, which contains a cabinet shop 112 feet long; tin, upholstery and glazing shops, each 56 feet long, and a department for electrical work which is 70 feet long.

Other minor buildings include a dry kiln 80 feet by 20 feet; two dry lumber sheds; a concrete pit for fuel oil, 40 feet by 12 feet, and a septic tank, 45 feet by 12 feet. There are three depressed tracks with concrete walls at the sides of the excavations. One of these tracks is at the northwest corner of the yard and is 250 feet long. It is adjacent to a scrap shed, 20 feet by 28 feet, and is intended for loading and unloading scrap.

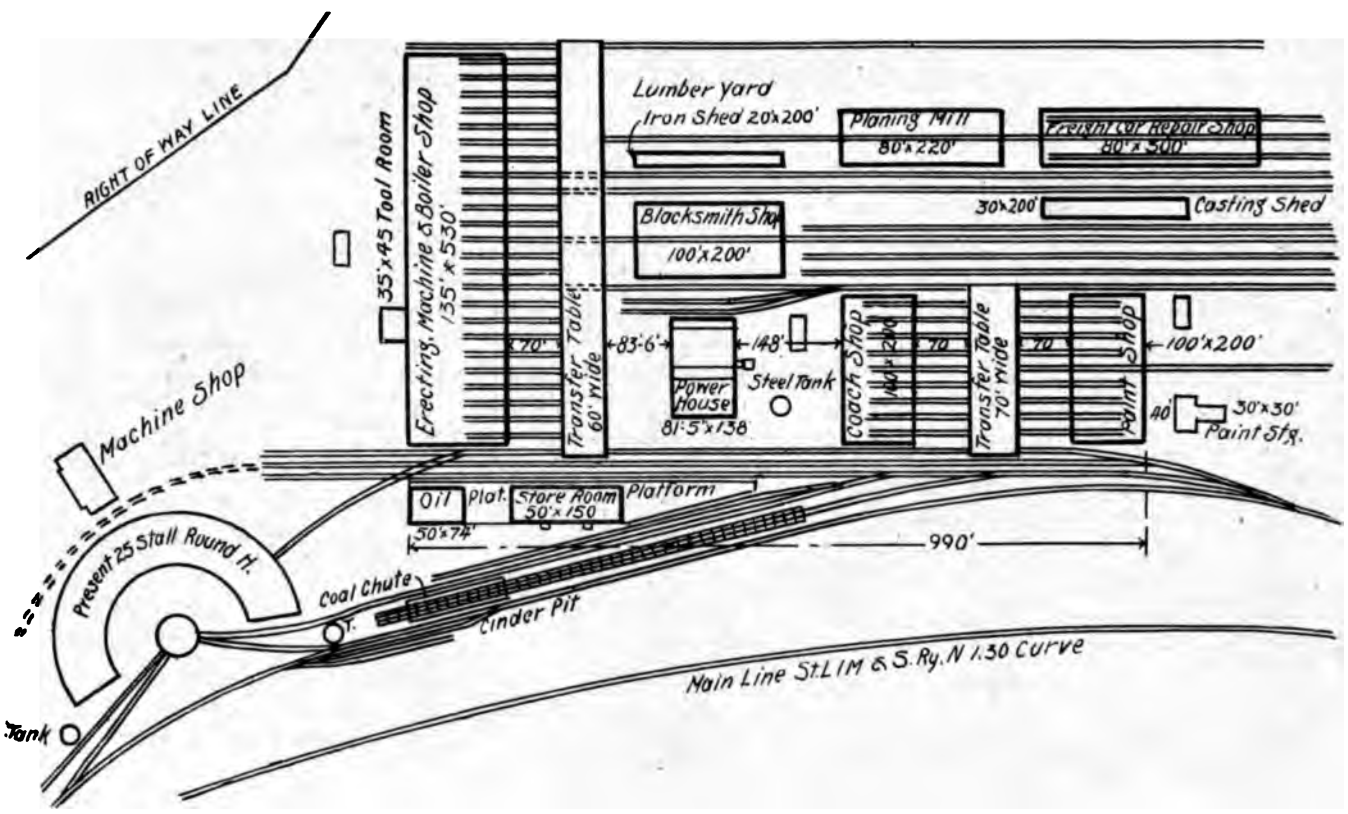
The minimum distance between buildings is 15 feet, while there are but few instances in which there is a maximum distance of over 85 feet.

There is a complete system of drainage and the sewerage is taken care of by the septic system, the tank for this purpose being located at the extreme east end of the shop ground and of dimensions as heretofore given. There are two laboratory buildings conveniently located, each 42 feet 8 inches long by 22 feet wide.

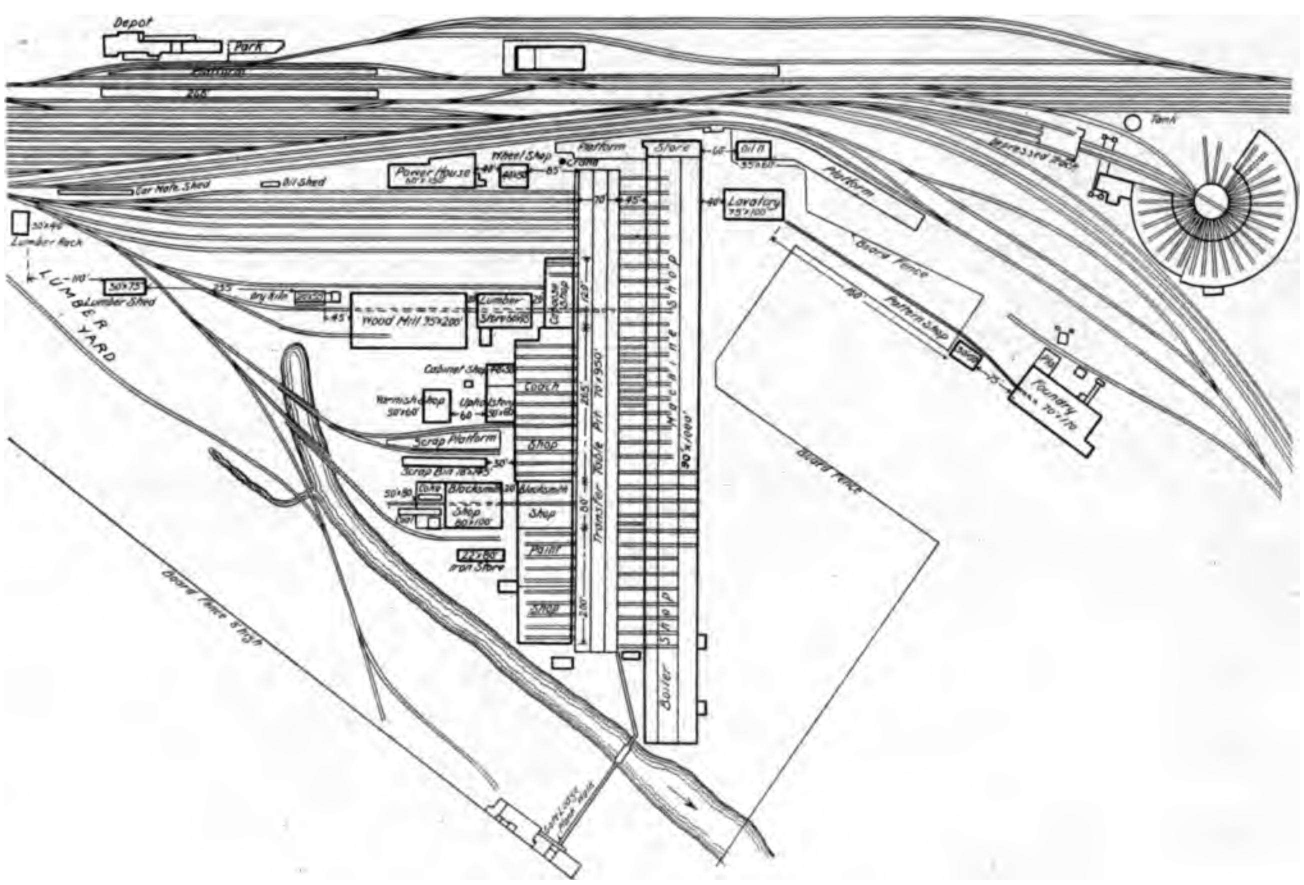
The general layout provides for an arrangement of buildings, material yard, working tracks, supply tracks, etc., by which material passes from its source through the various buildings, machinery and departments to its destination with productive movement and without doubling its course.

SUMMARY.

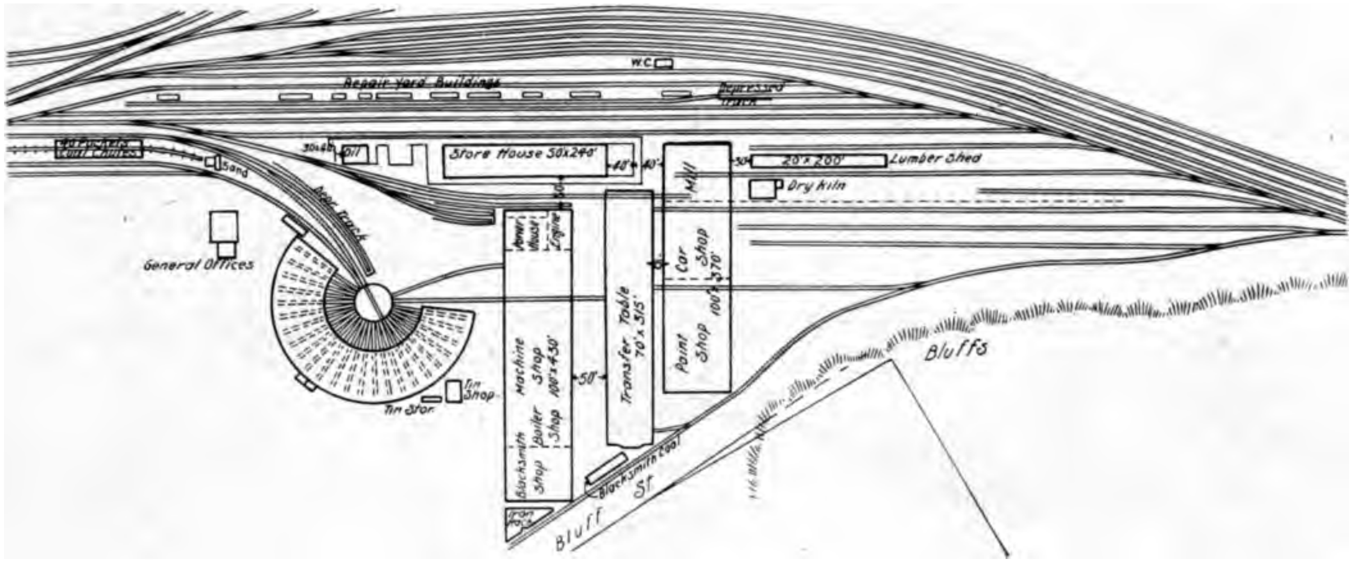
These several examples are cited for the purpose of calling attention to certain characteristic features prominent in the layout arrangement of the plants mentioned. It is believed that by pointing out such features of the individual shops, greater weight will attach to each case than would obtain as a result of a mere general reference and more reasonable deductions may be drawn. The selection of a single existing shop typical of American ideas, or representative of best practice for all conditions or to meet the requirements of any road is practically impossible, and it is therefore necessary to study the peculiar governing conditions affecting the requirement of a single shop and design accordingly, as no special rule can be devised in such regard.



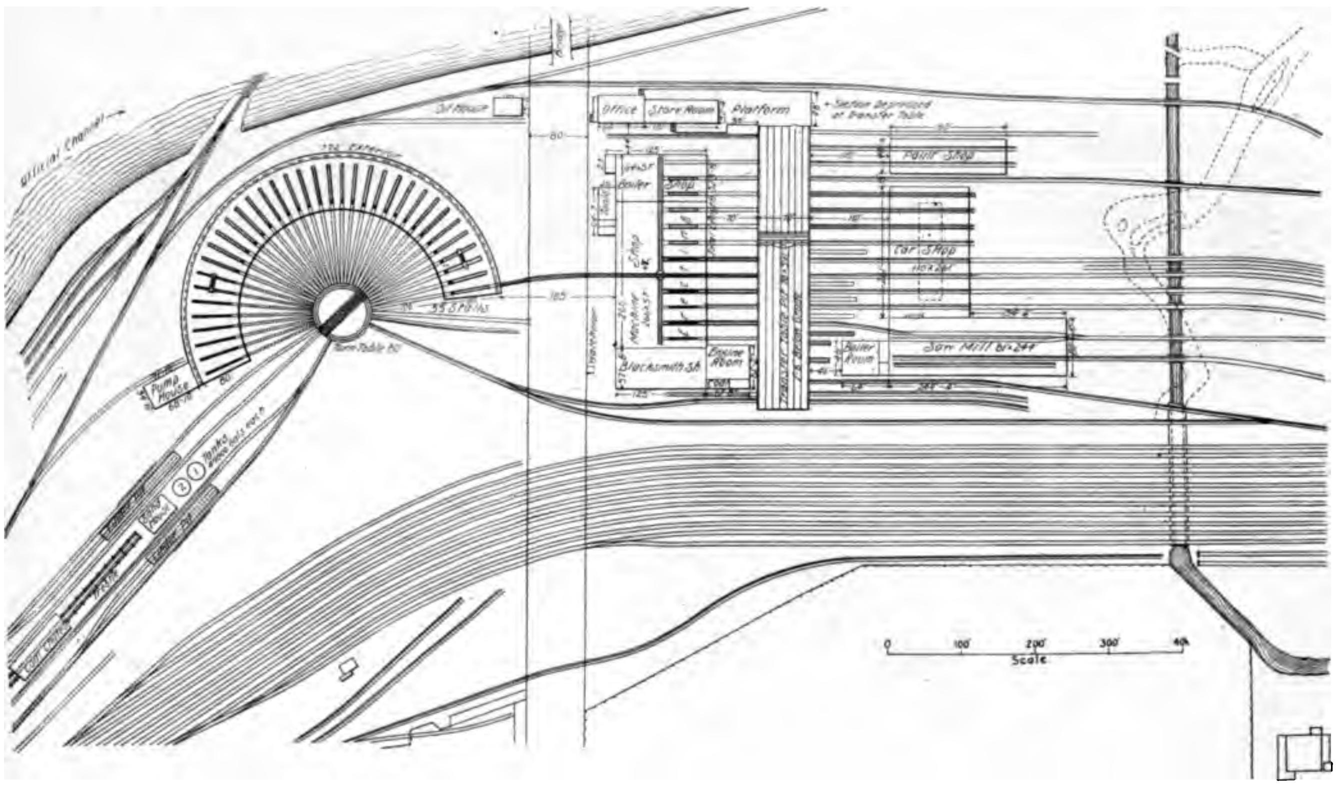
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE ST. LOUIS, IRON MOUNTAIN & SOUTHERN RY. AT BARING CROSS, ARK.—ACCESS TO LOCOMOTIVE SHOP BY INDIVIDUAL TRANSFER TABLE, TO FREIGHT CAR SHOP BY TRACK APPROACH, TO PASSENGER COACH AND PAINT SHOPS BY INDIVIDUAL TRANSFER TABLE.



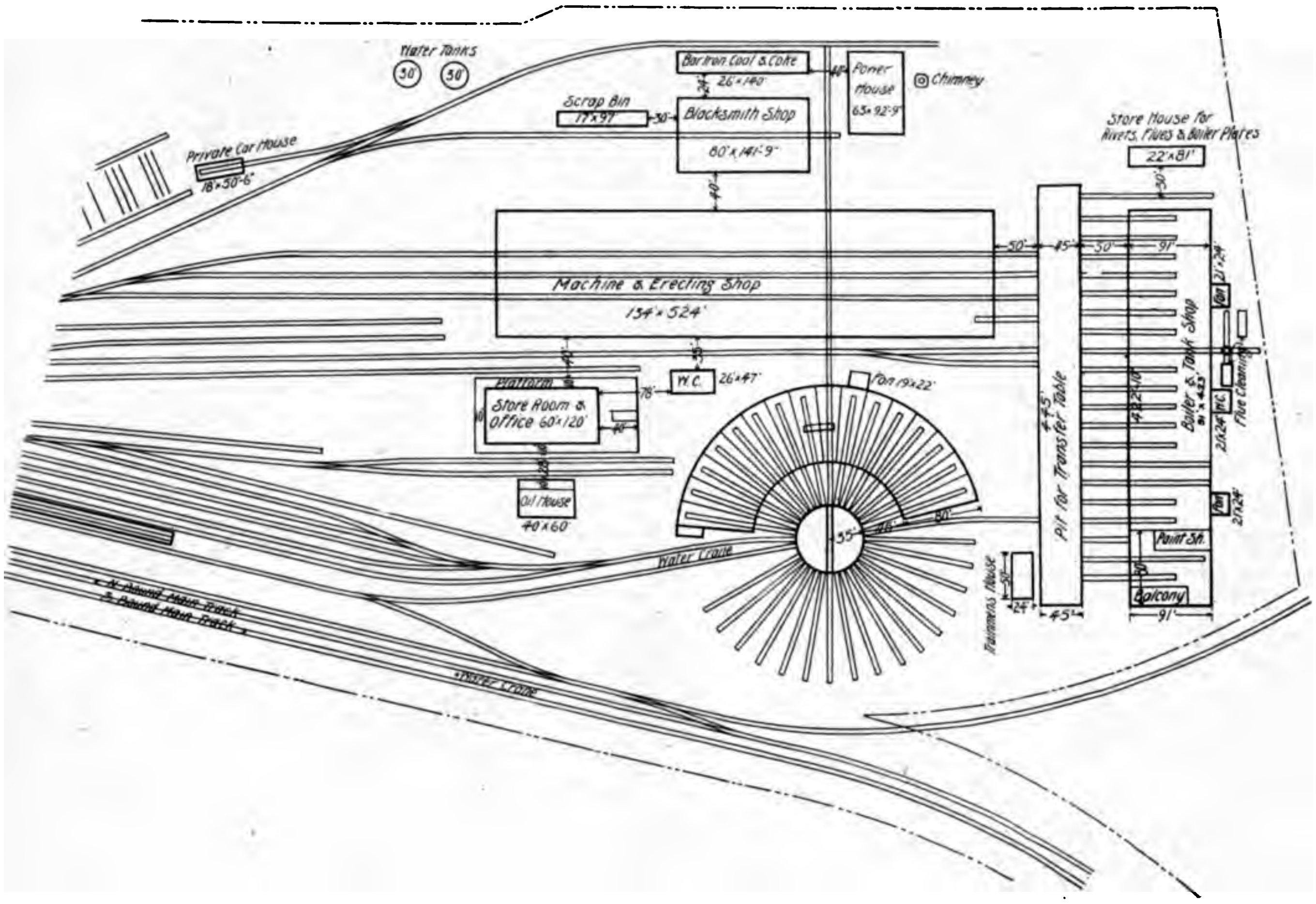
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE CHICAGO GREAT WESTERN RY. AT OELWEIN, IA.—ALL DEPARTMENTS SERVED BY SINGLE TRANSFER TABLE.



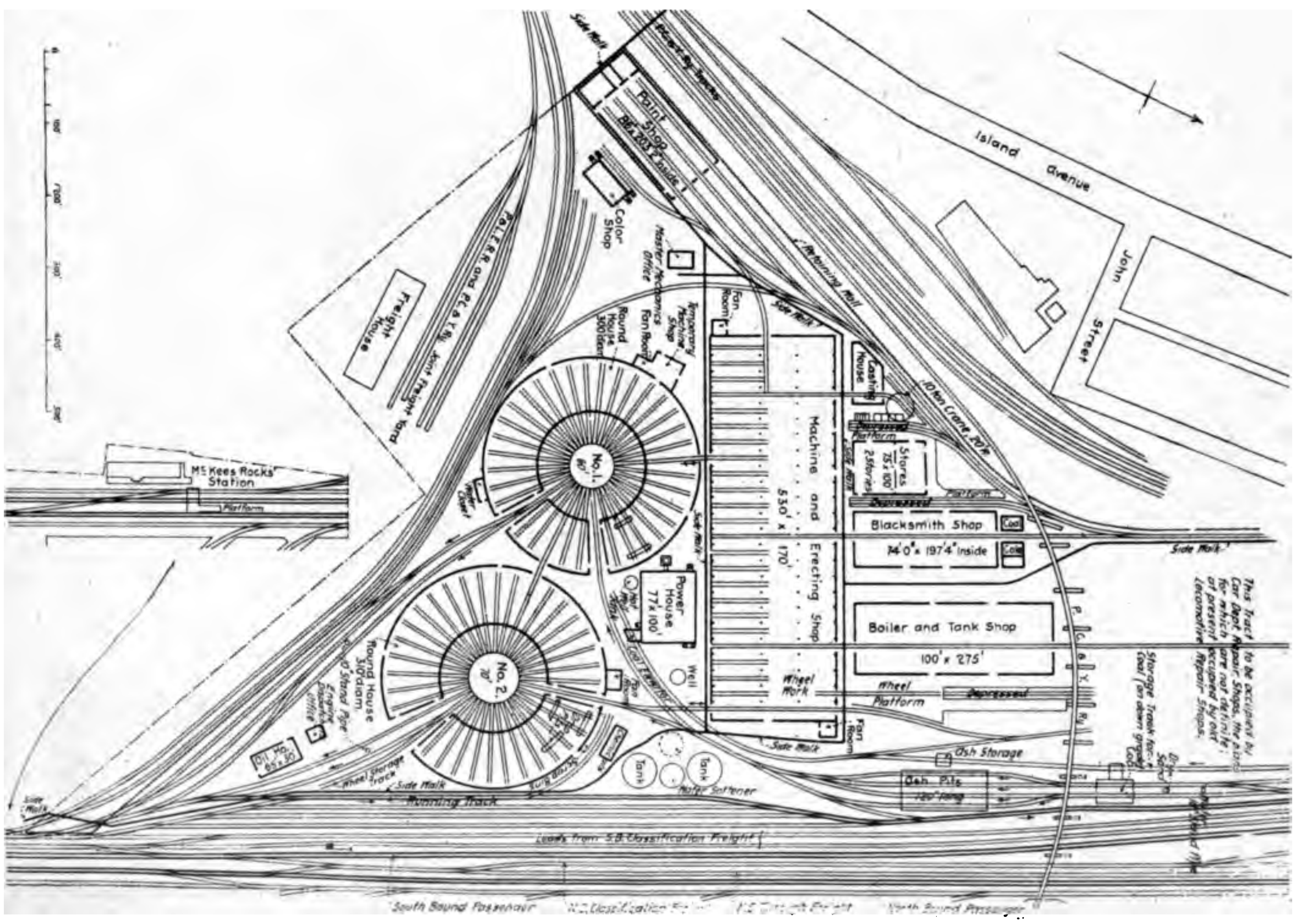
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE CHICAGO, BURLINGTON & QUINCY RY. (H. & ST. J.) AT HANNIBAL, MO.—ALL DEPARTMENTS SERVED BY SINGLE TRANSFER TABLE.



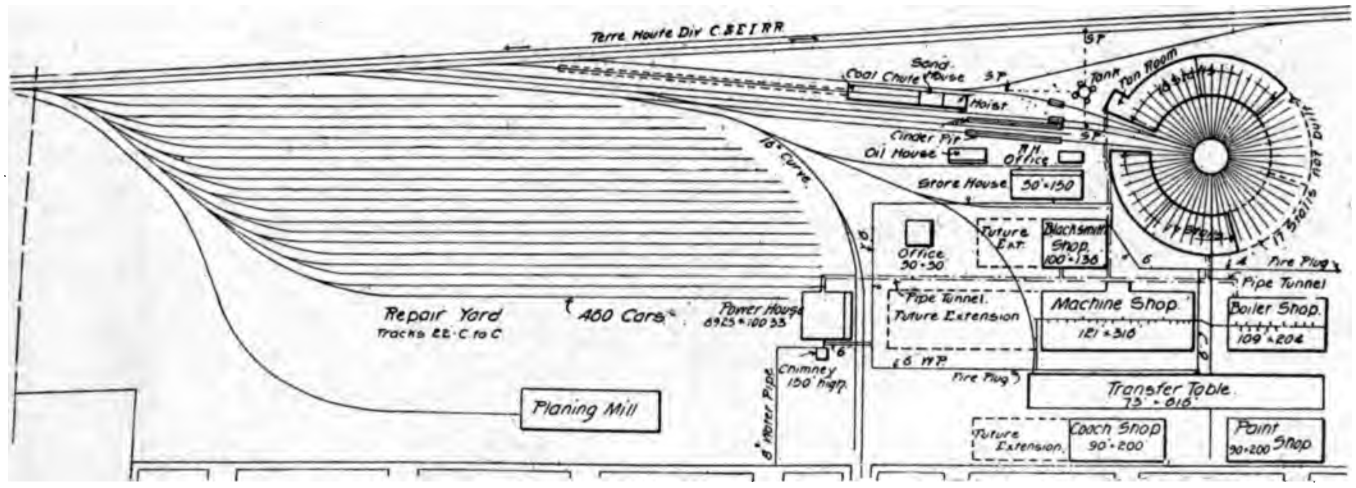
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE COLORADO & SOUTHERN RY. AT DENVER—ALL DEPARTMENTS SERVED BY SINGLE TRANSFER TABLE.



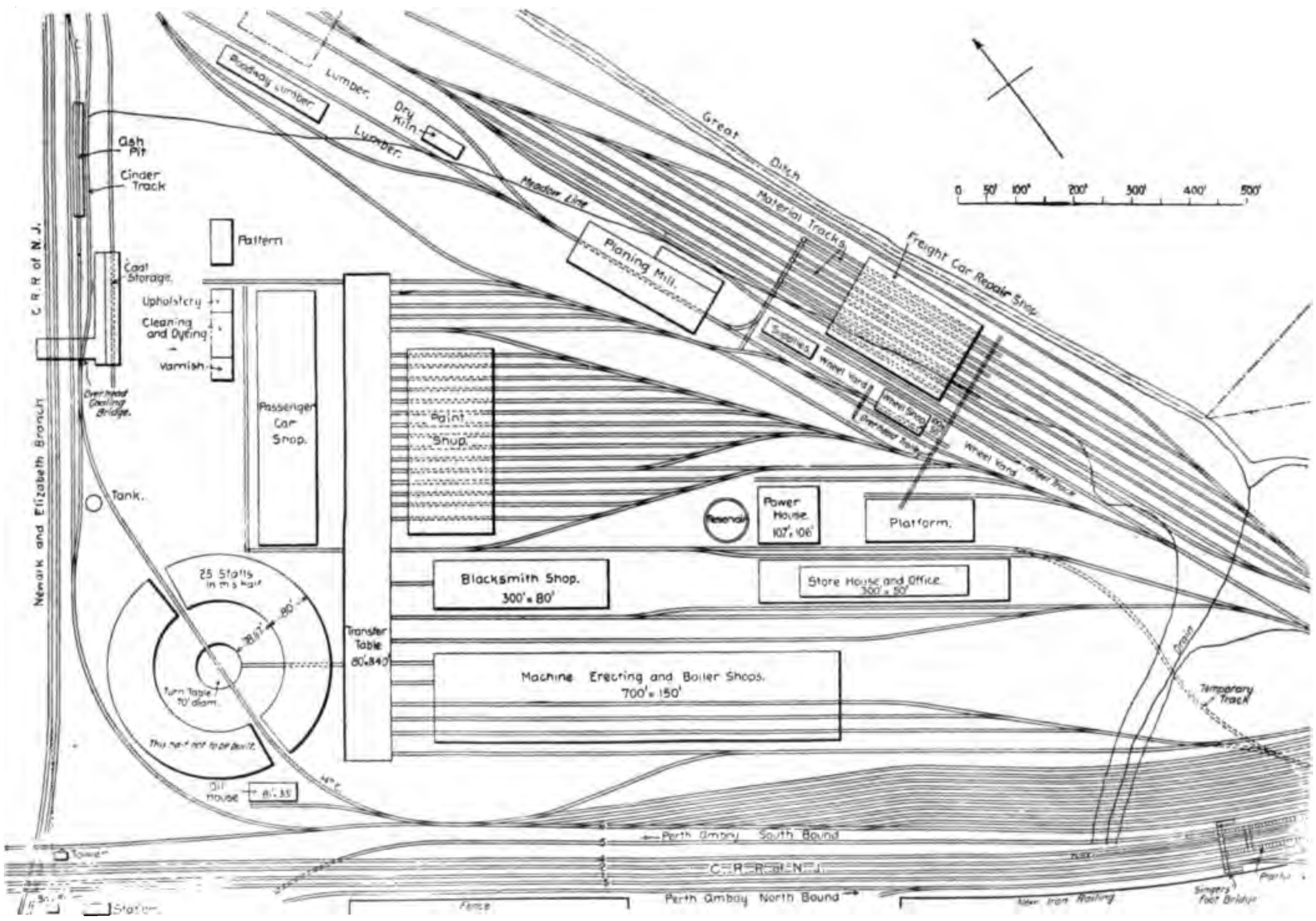
GENERAL LAYOUT—LOCOMOTIVE SHOPS OF THE BUFFALO, ROCHESTER & PITTSBURG RY. AT DU BOIS, PA.—LONGITUDINAL LOCOMOTIVE SHOP AND ISOLATED TRANSVERSE BOILER SHOP SERVED BY TRANSFER TABLE—ACCESS TO LOCOMOTIVE SHOP BY TRACK APPROACH AND TRANSFER TABLE.



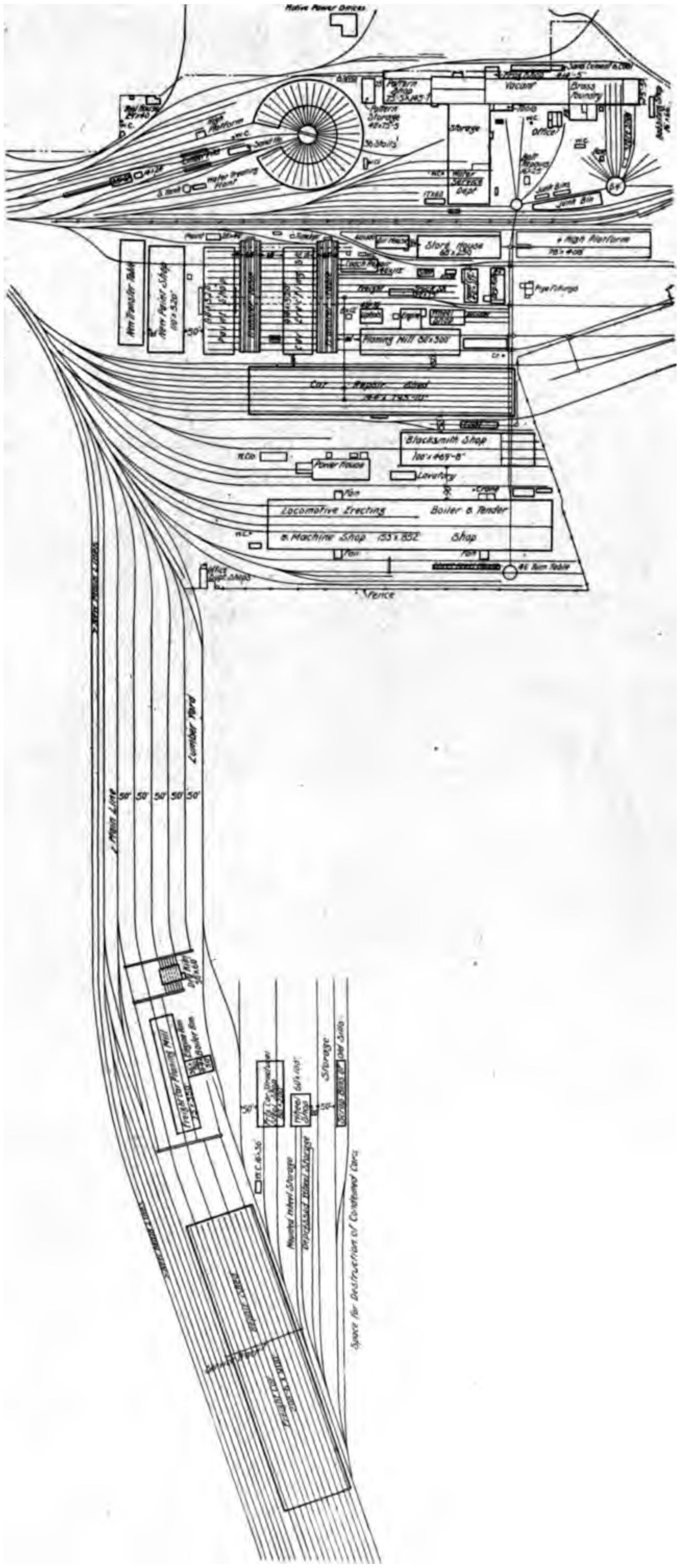
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE PITTSBURG & LAKE ERIE R. R. AT McKEES ROCKS, PA.—TRANSVERSE LOCOMOTIVE SHOP WITH ACCESS FROM ROUNDHOUSE TURNTABLE—BOILER SHOP IN ISOLATED BUILDING—MINIMUM DISTANCE OF 25 FEET BETWEEN BUILDINGS.



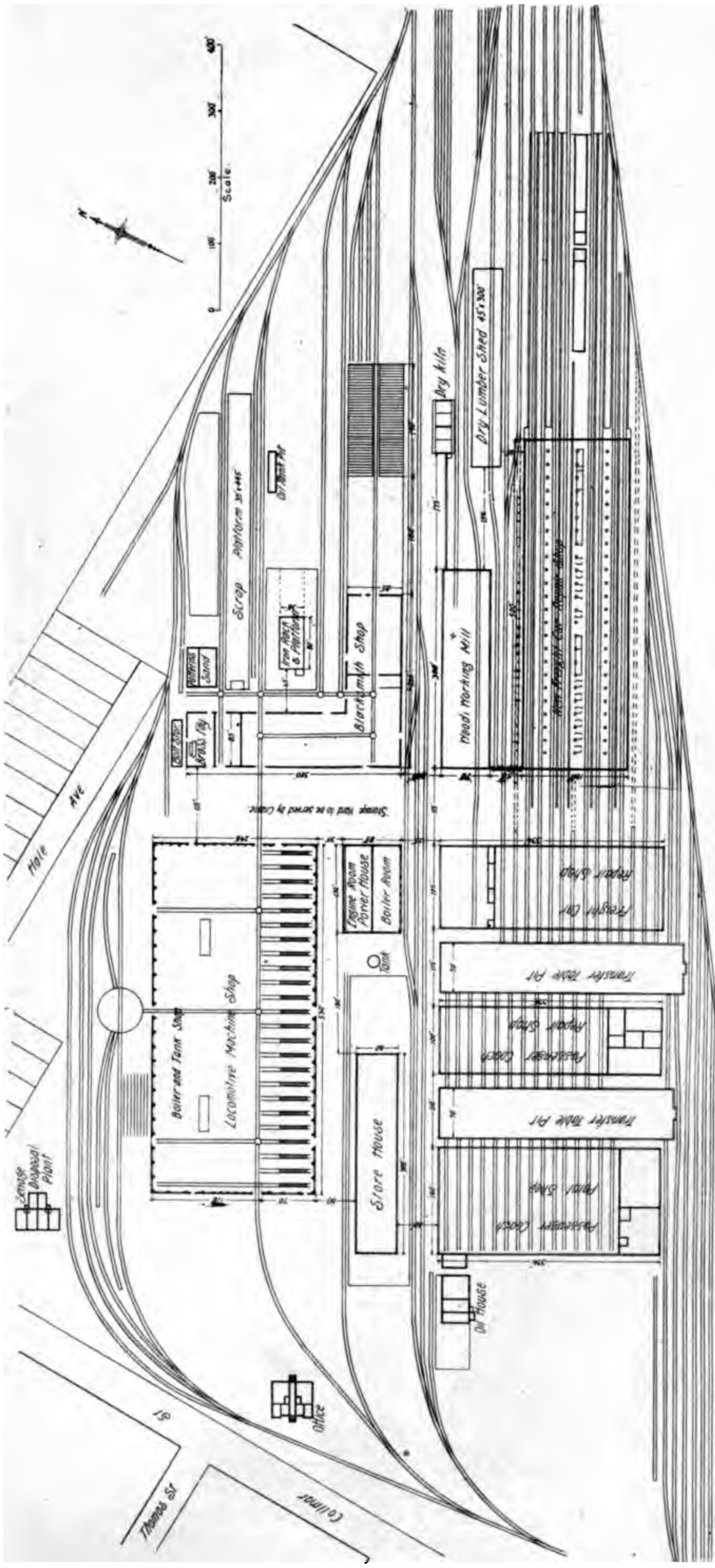
GENERAL LAYOUT—LOCOMOTIVE SHOPS OF THE CHICAGO & EASTERN ILLINOIS RY. AT DANVILLE, ILL.—ALL BUILDINGS TRIBUTARY TO ROUNDHOUSE—LOCOMOTIVE AND BOILER SHOPS SERVED BY SINGLE TRANSFER TABLE.—PROPOSED PASSENGER COACH AND PAINT SHOPS WILL BE SERVED BY COMMON TRANSFER TABLE AND ACCESS TO FREIGHT CAR SHOP WILL BE BY TRACK APPROACH.



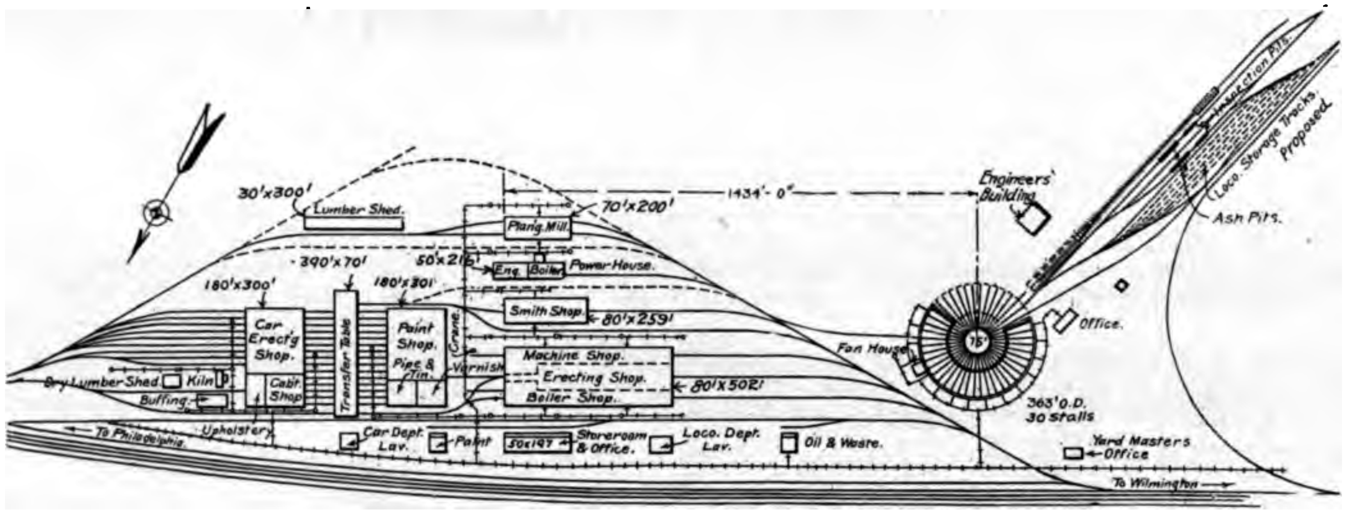
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE CENTRAL R. R. OF NEW JERSEY AT ELIZABETHPORT, N. J.—ACCESS TO LONGITUDINAL LOCOMOTIVE SHOP AND TO PASSENGER COACH AND PAINT SHOPS BY SINGLE TRANSFER TABLE—PROPOSED LONGITUDINAL FREIGHT CAR SHOP WITH TRACK APPROACH.



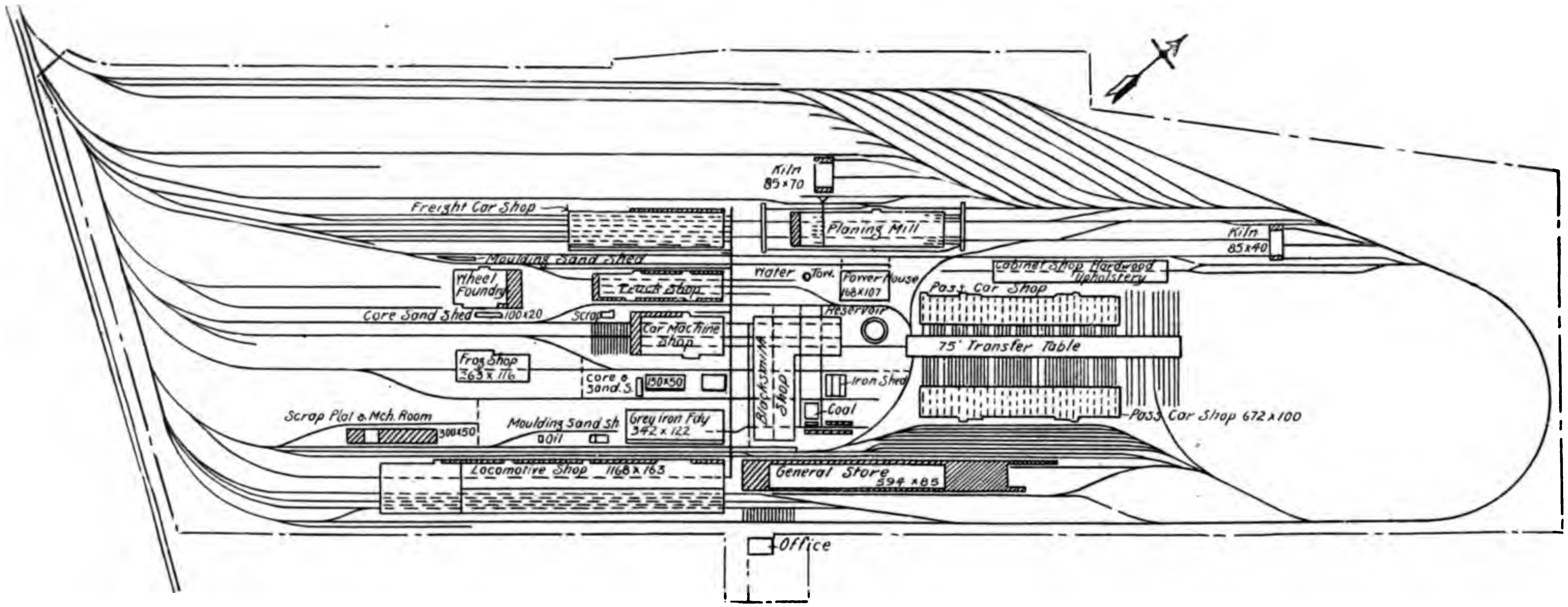
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE ATCHISON, TOPEKA & SANTE FE RY. AT TOPEKA, KAN.—ACCESS TO LOCOMOTIVE SHOP, TO TWO FREIGHT CAR REPAIR SHEDS AND TO FREIGHT CAR STRUCTURAL STEEL SHOP BY TRACK APPROACHES. PASSENGER COACH AND TWO PAINT SHOPS SERVED BY THREE TRANSFER TABLES.



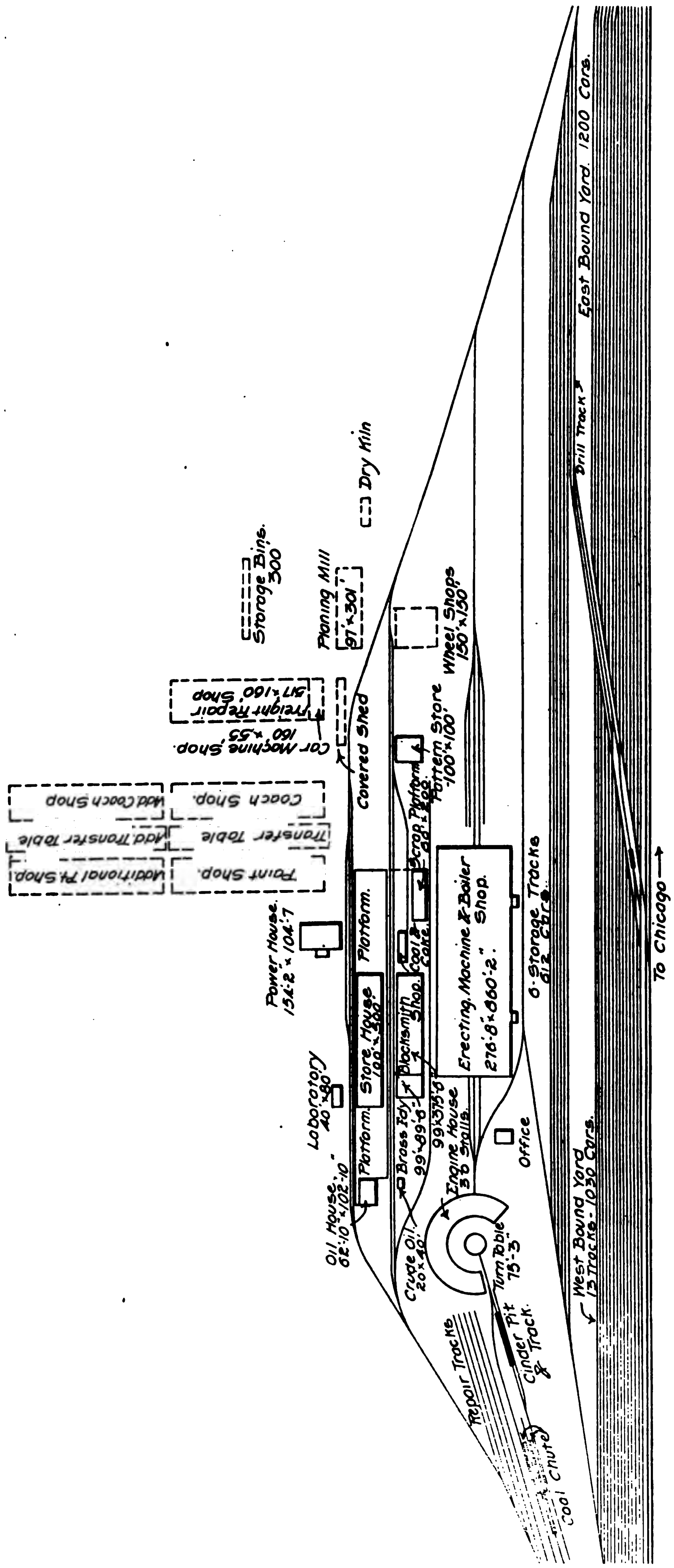
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE LAKE SHORE & MICHIGAN SOUTHERN RY. AT COLLINWOOD, O.—TRANSVERSE LOCOMOTIVE SHOP WITH ACCESS BY TURNTABLE.—PASSENGER CAR DEPARTMENT SERVED BY TWO TRANSFER TABLES. LONGITUDINAL FREIGHT CAR SHOP WITH TRACK APPROACH.



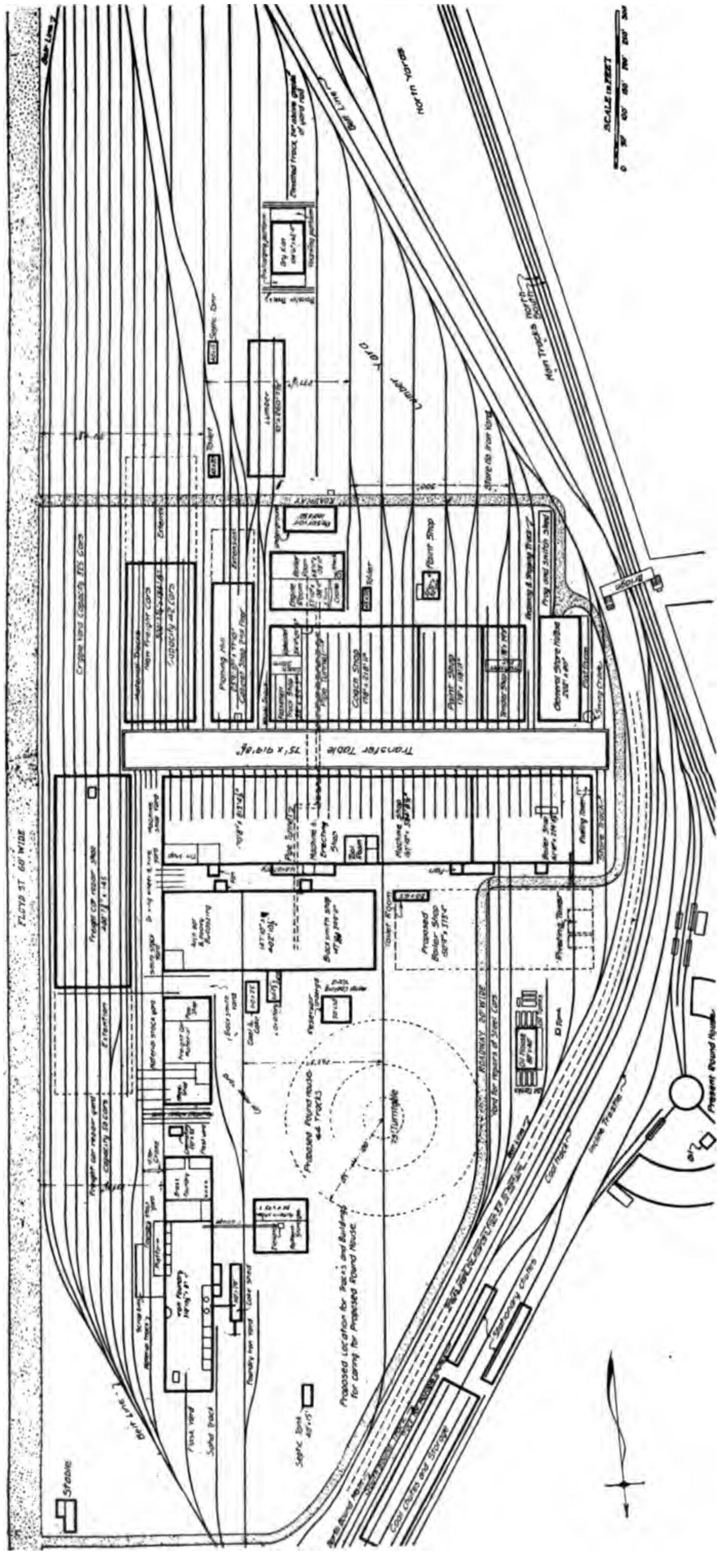
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE PHILADELPHIA, BALTIMORE & WILMINGTON R. R. AT WILMINGTON, DEL.—LONGITUDINAL LOCOMOTIVE SHOP WITH TRACK APPROACH AND PASSENGER CAR DEPARTMENT SERVED BY ISOLATED TRANSFER TABLE.



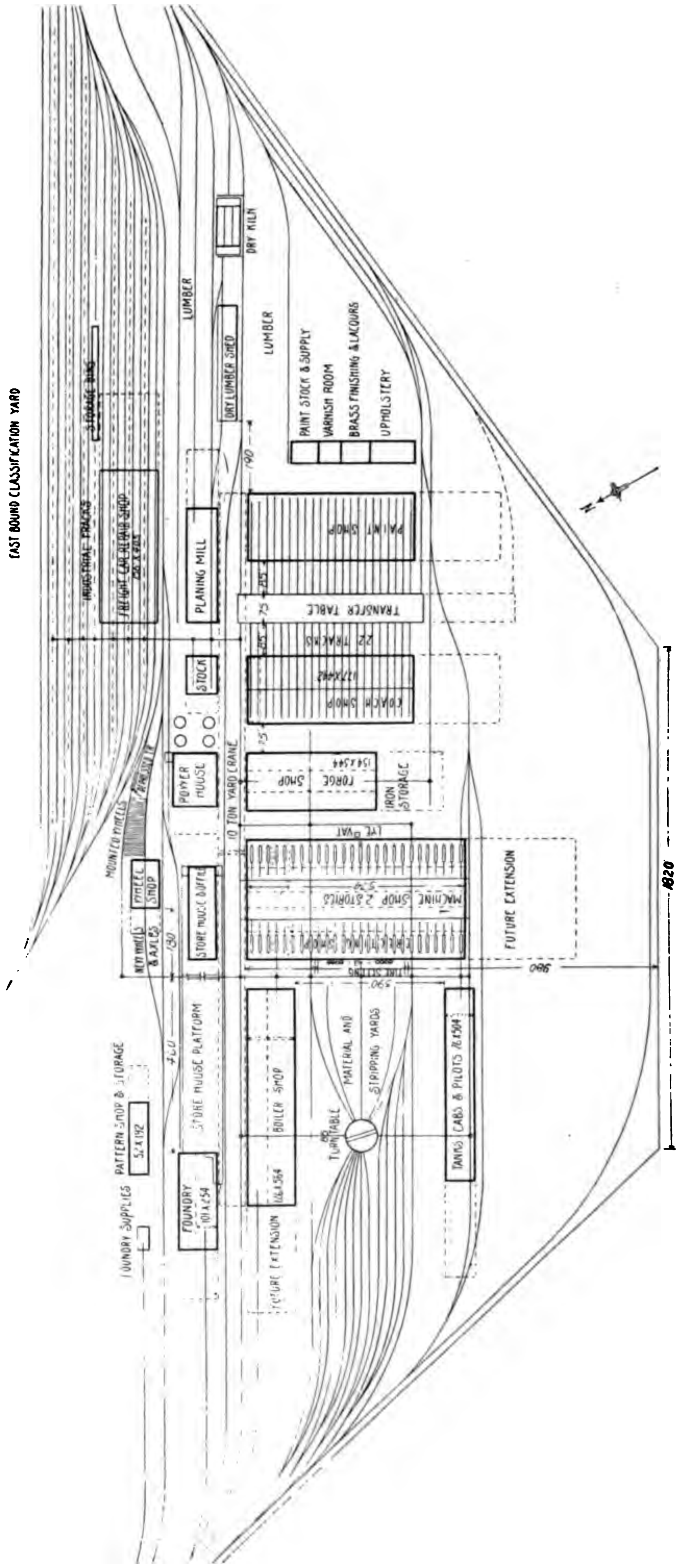
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE CANADIAN PACIFIC RY. AT ANGUS (MONTREAL)—PRINCIPAL BUILDINGS TRIBUTARY TO CRANE SERVED MIDWAY—ACCESS TO LOCOMOTIVE SHOP AND FREIGHT CAR SHOP BY TRACK APPROACH AND TO PASSENGER COACH AND PAINT SHOPS BY TRANSFER TABLE.



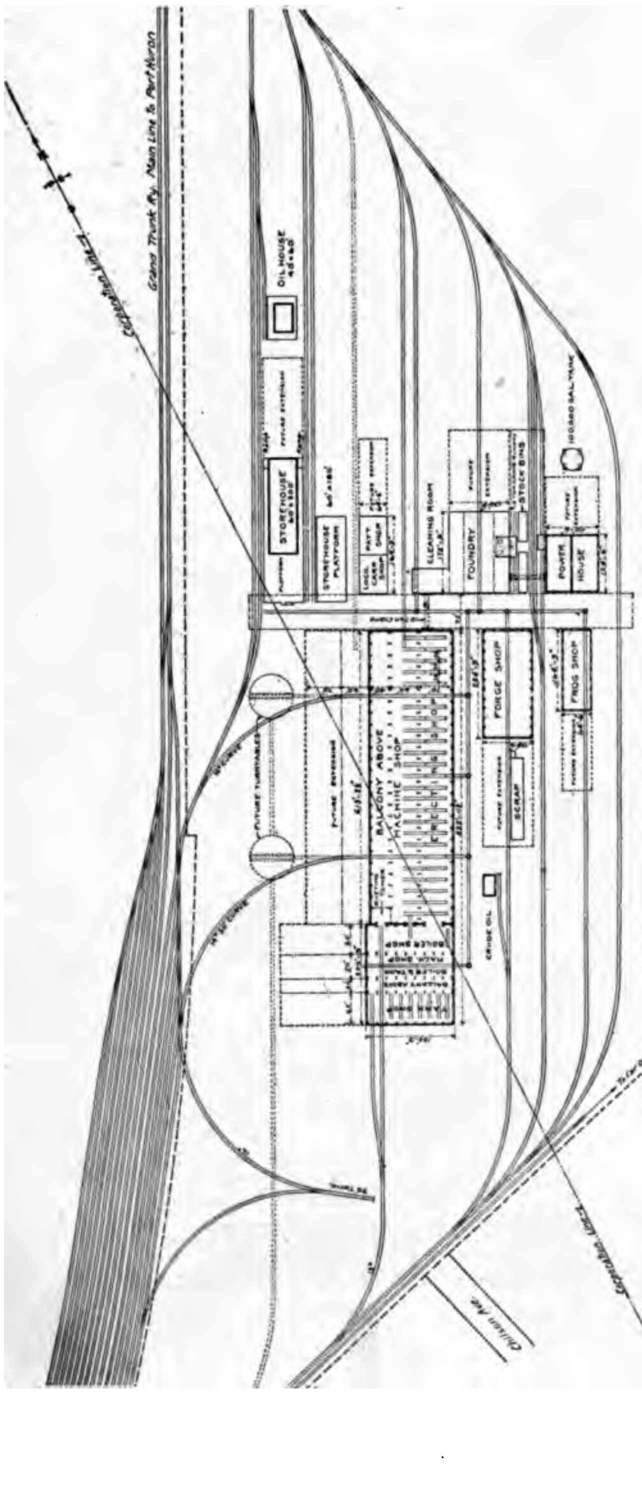
GENERAL LAYOUT—LOCOMOTIVE SHOPS OF THE CHICAGO, ROCK ISLAND & PACIFIC RY. AT SILVIS, ILL.—DIAGONAL LOCOMOTIVE SHOP WITH TRACK APPROACH FROM ROUNDHOUSE—PROPOSED PASSENGER CAR DEPARTMENT WILL BE SERVED BY ISOLATED TRANSFER TABLE.



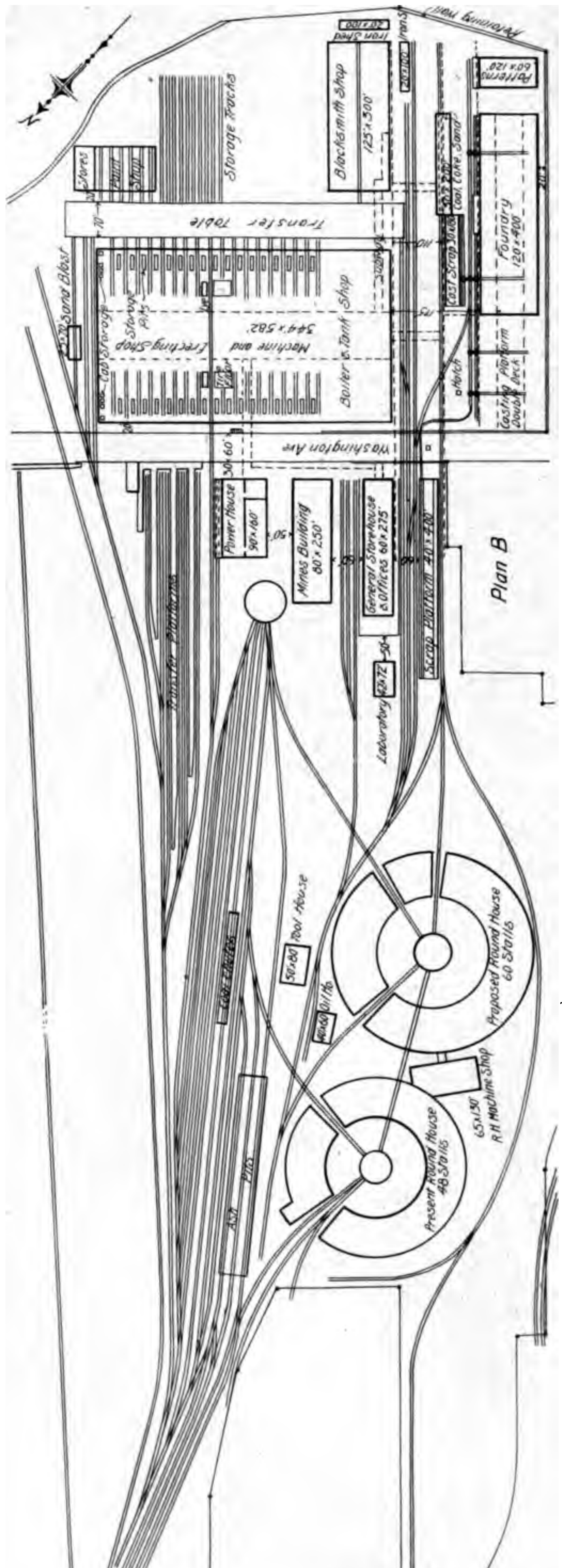
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE LOUISVILLE & NASHVILLE R. R. AT SOUTH LOUISVILLE, KY.—ALL DEPARTMENTS TRIBUTARY TO L SHAPED AVENUE OF DISTRIBUTION FORMED BY TRANSFER TABLE PIT AND CRANE SERVED STORAGE YARD.



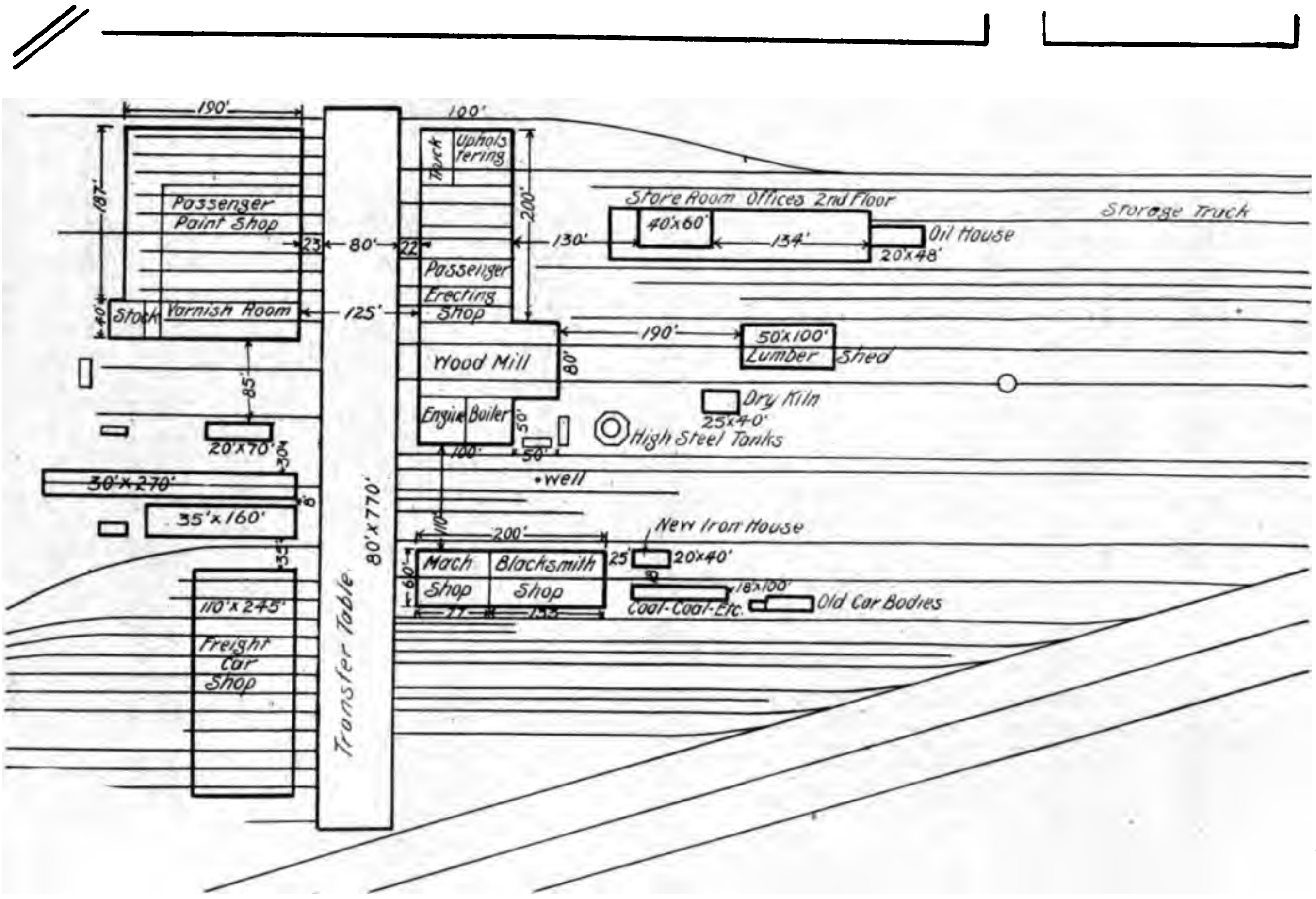
GENERAL LAYOUT—LOCOMOTIVE AND CAR SHOPS OF THE CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY. AT BEECH GROVE (INDIANAPOLIS)—TRANSVERSE LOCOMOTIVE SHOP WITH TRACK APPROACH; PASSENGER COACH AND PAINT SHOPS SERVED BY SINGLE TRANSFER TABLE; LONGITUDINAL FREIGHT CAR REPAIR SHOP WITH TRACK APPROACH, ADJACENT TO FREIGHT SWITCHING YARDS. PRINCIPAL BUILDINGS TRIBUTARY TO CRANE SERVED AVENUE OF DISTRIBUTION.



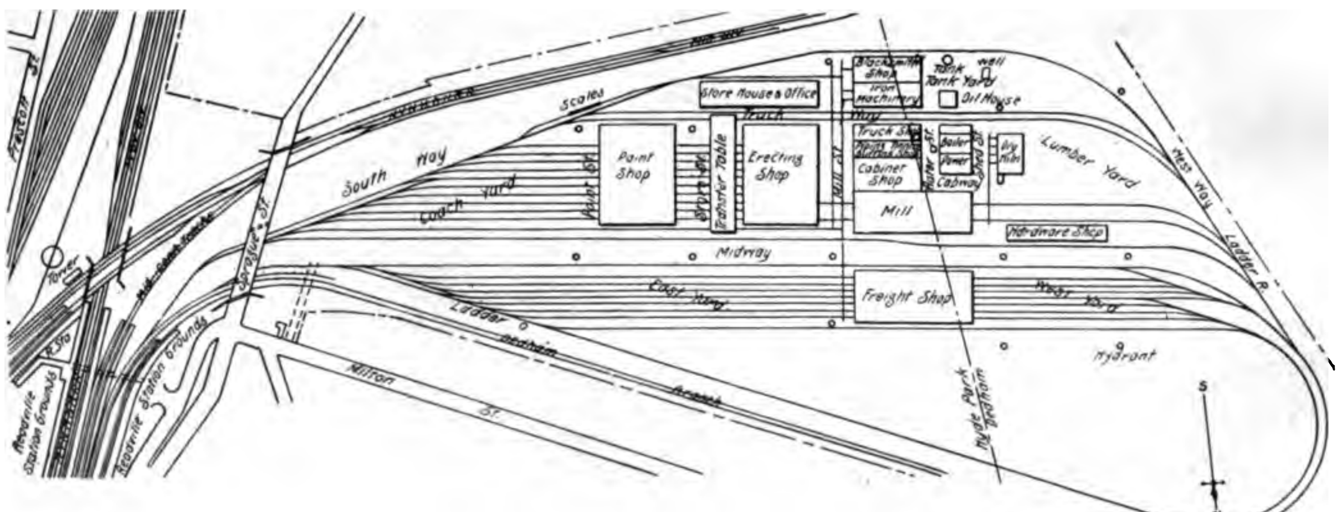
GENERAL LAYOUT—LOCOMOTIVE SHOPS OF THE GRAND TRUNK RAILWAY AT BATTLE CREEK, MICH.—TRANSVERSE LOCOMOTIVE SHOP. PRINCIPAL BUILDINGS TRIBUTARY TO CRANE SERVED AVENUE OF DISTRIBUTION.



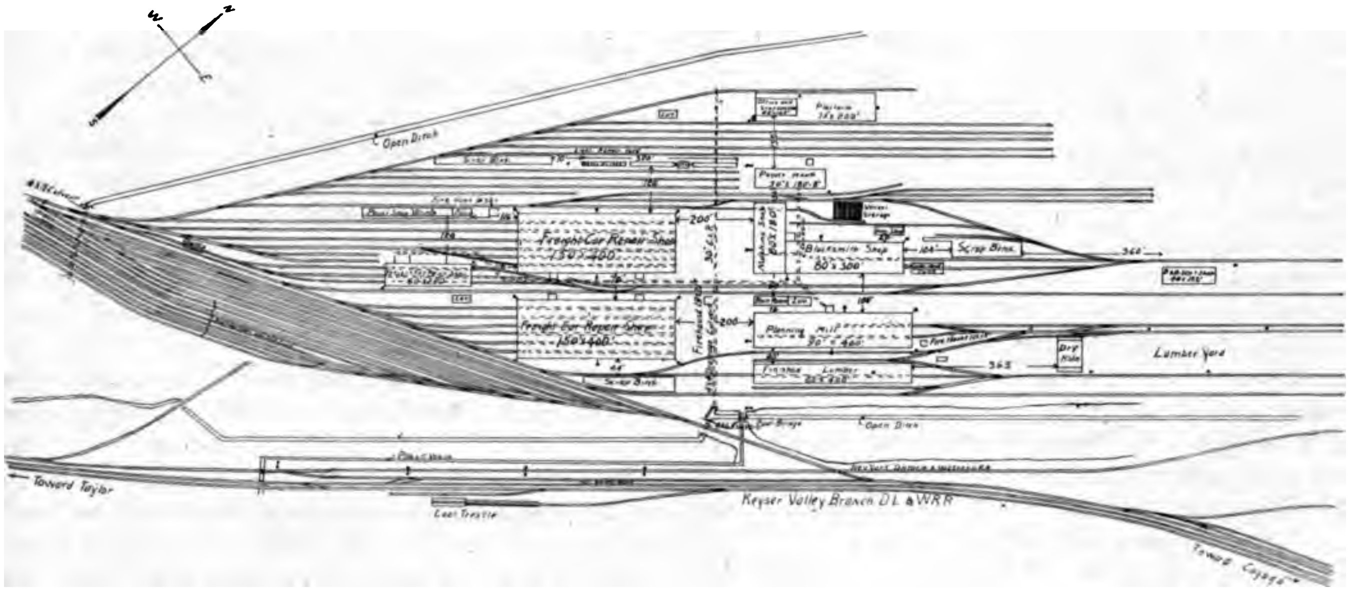
GENERAL LAYOUT—LOCOMOTIVE SHOPS OF THE DELAWARE, LACKAWANNA & WESTERN RAILROAD AT SCRANTON, PA.—TRANSVERSE LOCOMOTIVE SHOP WITH ONE ERECTING FLOOR SERVED BY TRANSFER TABLE. PRINCIPAL BUILDINGS TRIBUTARY TO CRANE SERVED AVENUE OF DISTRIBUTION.



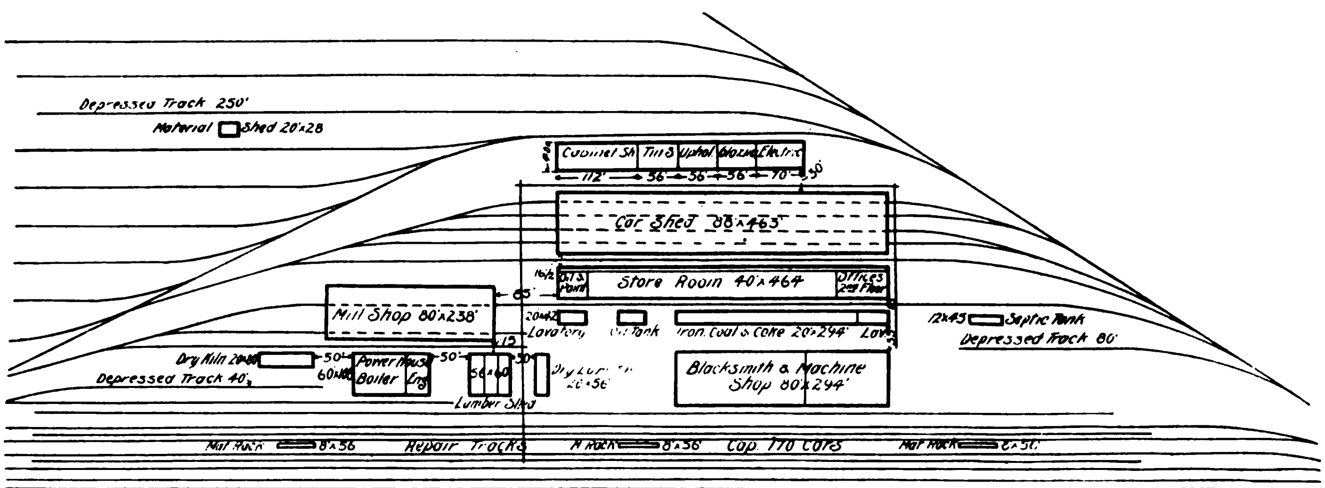
GENERAL LAYOUT—CAR SHOPS OF THE MISSOURI, KANSAS & TEXAS RY AT SEDALIA, MO.—ALL DEPARTMENTS SERVED BY SINGLE TRANSFER TABLE.



GENERAL LAYOUT—CAR SHOPS OF THE NEW YORK, NEW HAVEN & HARTFORD R. R. AT READVILLE (BOSTON), MASS. —ACCESS TO FREIGHT CAR SHOP BY TRACK APPROACH AT BOTH ENDS. PASSENGER COACH AND PAINT SHOPS SERVED BY SINGLE TRANSFER TABLE.



GENERAL LAYOUT—FREIGHT CAR SHOPS OF THE DELAWARE, LACKAWANNA & WESTERN R. R. AT SCRANTON, PA.—TRACK APPROACH TO ERECTING SHOPS AT ONE END.



GENERAL LAYOUT—CAR SHOPS OF THE WABASH R. R. AT EAST DECATUR, ILL.—LONGITUDINAL ERECTING SHOP WITH TRACK APPROACH—FREIGHT REPAIRS IN THE OPEN.

Railway Shop Up to Date

Chapter III

LOCOMOTIVE SHOP

THE SHOP BUILDING.

THE many prevailing conditions affecting the repairs of locomotives on a business basis, have brought about extensive changes in the buildings and equipment devoted to this class of work. Modern shops bear no resemblance to the antiquated structures once used for locomotive repairs.

While the buildings are free from expensive architectural embellishment, locomotive shops now are splendid structures, representative of the latest and most careful design, embracing stability, strength, natural lighting, heating, ventilating and sanitary requirements, and compare well with the facilities of modern industrial concerns.

Up-to-date locomotive shops are housed in brick buildings, in which the walls are tied to steel skeletons for stability. The roofs are supported by the steel skeleton structures and not only provide protection against the elements for men and equipment, but ample natural lighting.

The design of the locomotive shop building is made from an engineering viewpoint rather than an architectural one, and the details of placing machine tool equipment, erecting pits, provision of crane service and all auxiliary features, are as carefully planned for the particular purpose of the shop as are the details of a machine for a given class of work.

The practice at present is to build the locomotive shop with a clear height from floor to roof trusses, to provide for the operation of overhead traveling cranes and to offer no obstruction to natural lighting throughout the building, as well as to insure against shadows. In some instances a long narrow balcony, or gallery, occupies a position along one side wall and is located over a section of the main floor containing such machine tool equipment and minor departments as do not require continuous crane service. Such departments are then dependent upon windows in side walls for light.

Inasmuch as the buildings are long and narrow with usually at least three bays, the windows in the end walls provide but little light except at the extreme ends of the building and the windows in the side walls are at such distance from the central bay as to provide but little light therein. Therefore the most effectual buildings are those having side walls with windows extending nearly to the roof and in which the construction is such as to provide large windows above the roof of the lower bays to admit light to the higher bay. For instance, where the erecting floor is in the main, or central, bay such construction provides for large windows above the roofs of the side bays to admit light to the central bay, and a similar construction is modified to provide windows to admit light above the roof of the machine tool bay when the erecting floor occupies the side bay.

In recent years the saw tooth type of roof has been largely introduced in locomotive shops to provide natural light. The tendency is to place the glass in skylights in a vertical plane or nearly so, in order to provide against the uncomfortable effects of the direct rays of the sun.

The most prominent instances of the use of the saw tooth roof are at the Topeka shop of the Atchison Topeka & Santa Fe, where such a type of roof is used over the two side bays containing the machine tool equipment; at the Sayre shop of the Lehigh Valley, where the entire roof is nearly flat and the inner bays are dependent upon the skylights for the principal daylighting, and at the McKees Rocks shop of the Pittsburg & Lake Erie, where the two machine tool bays are on the same side of the erecting bay and where both of these bays are covered by the same flat roof at a lower level than the roof over the erecting bay.

The principal dimensions of the shop depend on the number and size of locomotives maintained and built per year, the class of work, and the amount of manufacturing done for shops along the line and for other departments.

As the latest design of locomotive shops has been confined largely to main shops, the examples of best practice are selected from among those erected for general and heavy repairs. It is the custom in some of these to build a few new locomotives each year, as such work provides an equilibrium of the forces, during periods of light and heavy work on repairs, and aids a satisfactory and permanent organization.

For locomotive shops it has long since been decided that the erecting and machine departments should be in the same building, but different opinions exist with regard to their relative locations and to the arrangement of pits. There are mechanical men who advocate arranging the erecting floor in two wings at right angles to the machine floor as at the West Albany and Depew shops of the New York Central. The arrangement of pits in one side bay and the location of machines in parallel side bays, as at the Angus shop of the Canadian Pacific and the McKees Rock shop of the Pittsburg & Lake Erie, is preferred by others, while, still others prefer an arrangement with a center bay containing the erecting pits and machine bay on each side, as at the Topeka shop of the Atchison Topeka & Santa Fe and at the Du Bois shop of the Buffalo, Rochester & Pittsburg. Attention is just now directed toward the plan of locating the machine bays between two rows

of transverse erecting pits as at the Sayre shop of the Lehigh Valley.

While several different plans have been mentioned, the prevailing shop construction indicates a preference for a long building with erecting and machine floors in parallel bays. Though there is a marked difference in the details of various shops, this feature is generally used in up to date shops, as securing the most intimate relation between the two departments.

The design and construction of several locomotive shops conceded to be representative of good modern practice, and erected in such sequence that their characteristics might justly be considered as tending to establish a precedent, embrace the boiler and tank shop within the same building as the erecting and machine shop. Such a locomotive shop is regarded with much favor among a large number of railway mechanical officials, but there are many, on the other hand, who prefer the boiler and tank shop in a separate building.

The most common arrangement according to the former practice provides for an assemblage of long narrow bays, within the limits of a single building, and the location of the boiler and tank department as a continuation of the erecting and machine departments without a definite division between them. Such an arrangement secures an extended scope for the use of traveling cranes, and allows a large area to be served without necessitating an excessive crane span. By locating the boiler department as an extension of the other two, a free use of the crane is available for transferring boilers, tubes, plates and other material, and by dispensing with a curtain wall, or other limitations of the boiler shop area, a more flexible arrangement of the shop is provided.

LOCATION OF BOILER DEPARTMENT.

The operation of large locomotive shops shows that in designing shops of this kind it is difficult to determine definitely how much space should be devoted to each department, and, as locomotive designs change, or as the motive power becomes older, or as the amount of manufacturing for other points on the road increases, one department is likely to become overcrowded. It is therefore considered expedient that the erecting, machine and boiler (including tank) departments should be so arranged that their limits may be changed readily to suit new conditions.

This practice, however, was not followed in the construction of the Louisville shop of the Louisville & Nashville Railway. The erecting floor is separated from the boiler department by a permanent curtain wall which determines absolutely the limits of each department. The wall is of such height as to permit continuous crane service between the two departments; but the management considers it more satisfactory to impose a limit to the floor space of each department.

At the Collinwood shop of the Lake Shore and Michigan Southern, while the boiler department is within the locomotive shop building, it occupies a side bay and is not arranged as a longitudinal continuation of the other two departments. This shop is composed of four long narow bays. The locomotive erecting floor and the boiler department occupy the outer bays, while the machine tool department occupies the two intermediate bays, with the heavier machine tool equipment in the bay nearer the erecting floor. Such a relation between the erecting floor and boiler department requires a greater amount of handling in the delivery of tubes, etc., between the two departments than obtains in a shop where both are served by the same crane and also requires a greater number of movements over the middle track connecting the departments and serving as the delivery track for locomotives.

PROPORTION OF DEPARTMENTS.

Of prime importance in the locomotive shop is the proper proportions between the various departments. In general, these are based on the locomotive erecting stall as a unit and the output of the shop is dependent upon the proper proportion of the other departments to so supply and promote work on the erecting floor that locomotives are repaired economically and returned to service in minimum time.

There is an evident diversity of opinion among railway officials regarding the proper proportions of locomotive shops. The areas of some recent shops are hardly indicative of best practice, in view of the additions to some departments which have been necessary in order to keep pace with the erecting department.

Principles upon which certain shops were designed, and the proportions based, have since been rudely upset by changes and developments in locomotive design. Greater steam pressures and larger boilers have increased the demands upon the boiler department, though, in some cases, this has been partially compensated for by the introduction of water treating methods which have materially increased the life of boilers; the introduction of cast steel in many details for which forgings were formerly used almost entirely, has affected the necessary size of the blacksmith shop by decreasing the demands upon that department; and the larger, heavier locomotives of today require greater machine tool equipment and more developed facilities for maintaining repairs.

In general, the machine tool area required to maintain locomotive repairs at minimum cost and maximum output, is considered to be at least fifty per cent larger than the area of the erecting floor. A shop equipped with from 6 to 8 machine tools per erecting pit might be expected to repair two locomotives per pit per month when operated with a good organization administered under a capable management. The output of the machines is the criterion, rather than the area of the department or the number of machines provided. The figures, therefore, are but approximate.

Generally speaking the required area of the boiler department is looked upon as being at least equal to the area of the erecting floor, and in many instances a boiler department 33 per cent larger is favored. The

proportion naturally depends upon governing conditions, such as the amount of new boiler construction, amount of work for other points on the road, character of water used, etc.

Considering the various factors involved in properly proportioning the departments as well as the conditions affecting locomotive repair work, it may be justly said that the size and standing capacity of the erecting floor does not limit the output of the shop. This limit is usually the machine space and machine tool equipment and by making them large in proportion to the erecting floor, a greater number of locomotives may be repaired per year on each standing space than could be turned out otherwise. The amount of work which can be obtained from one locomotive standing, or erecting space, is dependent upon the number of men employed and the work is flexible. If the machine space and equipment are not large enough to meet this demand, it is impossible to overcome this difficulty.

STORAGE OF LOCOMOTIVE SKELETONS.

A feature which should not be overlooked in connection with the locomotive shop is the provision of ample outside storage space for temporarily standing the skeletons of locomotives that are in the shop for firebox repairs. By placing the skeletons on special trucks and running them outside, while boiler work is being done, the machine work is taken care of at the same time and the frames, cylinders, etc., are not taking up valuable pit space which may be used to advantage by other engines.

NUMBER OF LOCOMOTIVE ERECTING PITS.

It has been said that good modern practice is to provide a number of locomotive repair pits equal to about 8 per cent of the number of locomotives to be maintained. However, information along this line is hardly conclusive and depends on a number of variable conditions.

ARRANGEMENT OF ERECTING PITS.

The arrangement of erecting pits, or stalls, for standing locomotives during repair work, is of much interest, though the selection of either the longitudinal or transverse system, seems rather one of personal preference than of actual advantage. While no conclusive evidence is available to show that a greater output is directly due to either arrangement, the selection of transverse pits for several shops on which construction work has been recently begun and for several others in which plans are now in preparation, would indicate that this arrangement is meeting with greater favor.

While earlier transverse shops required the service of a transfer table to facilitate delivery of locomotives to and from the several erecting pits, the introduction of overhead traveling cranes, capable of lifting and transferring the heaviest engines over others standing on the erecting floor, has so modified this requirement that there is a marked tendency to dispense ·h the transfer table as an adjunct to the locomotive shop. At the same time certain experiences would indicate that the transfer table is being considered again with favor in some instances in which it had been once precluded.

Early transverse shops, not served by transfer tables, required a fan tail approach to the erecting pits, connecting with the system of yard tracks or with the roundhouse turntable, and while there are a few old shops with such an approach still in service, this arrangement is no longer used for new designs.

Before the introduction of traveling cranes, longitudinal shops required an entering track for each working track and it was necessary for a locomotive to remain on the same track on which it entered the shop, until repairs were made and the locomotive was ready for delivery.

With present facilities, a locomotive may be stripped on one track and later delivered to any desired working space on the erecting floor. When it is ready for delivery, it is again transferred by the cranes, and no confusion need arise on account of a locomotive being blocked by others not as far advanced in the stages of repair.

It is now the universal practice to serve an erecting shop in which the stalls are arranged longitudinally, by at least two cranes traveling on the same level and of such capacity that a locomotive may be lifted and transferred by both of them operating together. A crane of smaller capacity traveling on the same runways, is sometimes installed to serve the boiler department and thus relieve the larger cranes.

At the Silvis shops of the Chicago Rock Island and Pacific Railway an unusual arrangement of pits has been introduced. The direction of the working pits is neither transverse nor longitudinal but is diagonal.

This layout is known as the "herring bone" arrangement and provides for the erecting pits at an acute angle with a longitudinal pit traversing the center of the bay, on which engines enter the shop. From the entering track a locomotive is transferred to a repair pit by two traveling cranes. The angle of the pits should be such as would be made by an average length locomotive, hanging from the hooks of two cranes when the cranes are about to approach each other. Due to an error in laying out the pits at Silvis the actual angle is such that the cranes interfere and it is necessary to lower one end of a locomotive and swing the other end into place when the first crane has moved a sufficient distance to allow the second crane to approach. The inconvenience caused by this condition has not been serious enough to justify tearing up the pits and rebuilding them at the proper angle. The experience of the Silvis shop would indicate that while this error causes some inconvenience, it does not by any means condemn the principle of so arranging locomotive repair pits. The center track has no pit except at the ends of the shop beyond the end diagonal pits.

The erecting shop of the Pennsylvania Railroad at Altoona contains three longitudinal pits, each extending the length of the shop. The entire floor is served by two cranes of 130,000 lbs. capacity. Each side pit is served by three wall cranes of 4,000 lbs. capacity. Locomotives enter and leave the shop on the center track, on which they are unwheeled and stripped upon entering and rewheeled after repairs have been made. They are transferred from the center track to the desired location on one of the other tracks where they are dismantled and erected, by the two traveling cranes.

The length of the arms of the wall cranes is such as to serve both sides of a locomotive conveniently and at the same time there is sufficient space between the ends of these arms and a locomotive standing on the center track, to allow a locomotive, being transferred by the heavy cranes, to pass between the center row of locomotives and the wall cranes without interference.

Such an arrangement allows a free scope for the cranes in both light and heavy service. The work of one set of cranes is allowed to continue without limiting the operation of the other and the congestion of crane service sometimes experienced on account of the limitations provided by both sets of cranes spanning the entire width of the floor is obviated.

Transverse erecting shops served by a transfer table are usually served by one crane capable of lifting a locomotive for unwheeling and wheeling, as at the Burnside shop of the Illinois Central and at the Danville shop of the Chicago and Eastern Illinois. Such a shop is sometimes served by a crane of light capacity for handling the smaller parts and by a crane capable of lifting a locomotive for unwheeling and wheeling, but which is not capable of lateral movement and is dependent upon the lighter crane for transportation. This method is followed at the Baring Cross shop of the Saint Louis, Iron Mountain and Southern and at the Oelwein shop of the Chicago Great Western. At the Grand Rapids shop of the Pere Marquette locomotives are wheeled and unwheeled by a stationary electric hoist serving a single pit. The erecting floor is served by a traveling crane of 20,000 lbs. capacity.

In transverse shops not provided with transfer table service, the erecting floor is served by a crane operating at such height and of sufficient capacity as to lift a locomotive and transfer it above those standing on the floor, and by a crane of about 10 tons capacity, operating at a lower level, for handling the lighter parts, as at the Collinwood shop of the Lake Shore and Michigan Southern, the McKees Rocks shop of the Pittsburg and Lake Erie, at the Sayre shop of the Lehigh Valley and others.

In a shop of this type, having 24 or more pits on one floor, operated to turn out more than two locomotives per month on each pit, the erecting floor should be equipped with two cranes on the upper level and each crane should be of such capacity as to transfer the heaviest locomotive when the boiler contains three gauges of water and there is a fire on the grate.

Advocates of both long and cross shops advance arguments in regard to dimensions of buildings, floor area, etc., in favor of one arrangement or the other but either arrangement chosen should be selected on account of its advantages from an operating standpoint rather than with regard to original cost of construction. It is worthy of note that a long shop seldom contains the number of engines at which its standing capacity was originally rated when the shop was put into commission.

Both designs lend themselves readily to a desirable general layout as is shown by the ground plan arrangements of the Angus shops of the Canadian Pacific and the Indianapolis shops of the Big Four. The former is a long shop and the latter is a cross shop. Each forms a part of a layout which presents great similarity in many respects and each is tributary to a crane served runway.

Much argument has been presented with regard to the necessity of a turntable in connection with a cross shop, for the purpose of heading engines into the shop, unless the shop is situated transversely with the line of yard tracks. Practically the same argument obtains with regard to the longitudinal shop, for, if the shop is not parallel with the yard system of tracks, engines entering the shop must traverse a turntable or curve.

With regard to the choice between cross and long shops it is interesting to note that in the two most recently constructed shops on the Pennsylvania Lines East, Olean, N. Y., and Trenton, N. J., the former is a transverse shop while the latter is longitudinal, a fact which would seem to indicate that the preference is not determined even among officers of the same road.

Inasmuch as the choice in arrangement of pits seems to be largely a matter of personal taste, it is interesting to view the discussion of the report of the committee on shop layouts presented at the 1905 meeting of the American Railway Master Mechanics' Association.

The committee reproduced in part the work on this subject by Mr. R. H. Soule, published in the American Engineer, who was originally chairman of the committee. Following a discussion of the two arrangements, Mr. Soule sums up the situation briefly in nine items of comparison and, in totaling these several items, attributes greater flexibility to the longitudinal shop for general use. His summary may be expressed as follows:

Item 1. With regard to layout the longitudinal shop can be placed parallel to a general line of tracks and entered by direct track connections, while with the transverse shop, if placed parallel to a general line of tracks, it must be entered by a turntable.

Item 2. From a structural standpoint, the distance between roof trusses over erecting floor in the lon-

gitudinal shop can be determined by conditions of economy alone. In the transverse shop this distance must be the same as spread of stalls tracks whether economical or not.

Item 3. The longitudinal shop is less compact and the transverse shop more compact.

Item 4. Considering access from other shops, in the longitudinal, traffic must be across the pits. In the transverse shop it is not necessary to cross the pits.

Item 5. Lighting, both day and night, is more difficult in the longitudinal shop and in the transverse shop is easier and better.

Item 6. In lifting engines in the longitudinal shop, it is necessary to lift them only high enough to clear driving wheels, consuming less time, while in the transverse shop engines have to be lifted high enough to clear adjacent engines, consuming more time.

Item 7. In moving engines horizontally in the longitudinal shop less distance is covered under average conditions. In the transverse shop more distance is covered under average conditions.

Item 8. In dropping engines on their wheels in the longitudinal shop this work includes more use of cranes and less manual labor (in handling wheels), while in the transverse shop this work is done with less use of cranes and more manual labor.

Item 9. As a summary of these various points, greater flexibility is attributed to the longitudinal shop and less to the transverse shop.

In discussing these several items Mr. F. F. Gaines, then mechanical engineer of the Philadelphia and Reading Railroad, argues as follows:

Item 1. The first item may be stricken out from general consideration as it applies only to localities where the ground space is limited and governs a design rather than the general utility of the shop itself.

Item 2. From data given in report it is seen that the width of bays necessary with either class averages nearly the same, being 65½ feet for the longitudinal, 68 feet for the transverse with cranes on one level and 63¼ feet for transverse with cranes on two levels.

Item 3. Admits desirability of transverse arrangement.

Item 4. Admits desirability of transverse arrangement.

Item 5. Admits desirability of transverse arrangement.

Item 6. Lifting engines: Unless at all times the middle track of the transverse shop is kept open, or sufficient space between the tracks is left for standing an engine, it will be necessary to lift the engines over other engines, either to bring them in or take them out. If the middle track is kept open or space between the tracks is allowed it becomes a very uneconomical distribution of floor space. On the other hand, granting it takes more time to lift engines in a transverse shop, which is questionable, the amount of such time is small and affects only a very small percentage of the force.

Item 7. For the same reasons as given under Item 6, it is questionable if it is at all favorable to a longitudinal shop.

Item 8. If the work is handled properly there is absolutely no difference in either system, in either time or manual labor.

Mr. Gaines adds two items not included in Mr. Soule's summary which cover the distribution of material. One refers to access to machines and movement of men to and from tool room and is very decidedly in favor of the transverse arrangement; and the other covers the storage of wheels, handling and storing locomotive parts during repairs, the transverse shop affording much more flexible arrangement as well as keeping the shop looking much neater.

Item 9, being a summary of various points for and against the two systems, would then appear as follows:

With Items 1, 2, 6, 7, and 8 equally favorable and Items 3, 4 and 5, in addition to the two items by Mr. Gaines, he considers the summary in favor of the transverse arrangement.

SIZE OF SHOPS.

The size of the shop is determined by the number of locomotives to be maintained and by the number which it is decided to turn out per year or per month. This determination is based upon the locomotive erecting or standing space as a unit, whether the arrangement of the erecting floor is on the transverse, longitudinal or diagonal plan. The past and present proportions of areas are hardly conclusive of best practice, yet to some extent they naturally form a guide for other shops under consideration, when sufficient data is available concerning the various governing conditions.

WIDTH OF ERECTING BAY.

In the longitudinal shop the distance between pits is an essential factor in the width (distance between crane columns) of the erecting bay. General usage has established three pits or tracks as common practice. In the earliest shops the distance between centers of pits was 18 feet and later 19 and 20 feet, until 22 feet is now considered the most satisfactory distance, though there are instances where this has been exceeded as at the Union Pacific shops at Omaha and the Atchison, Topeka and Santa Fe shops at Topeka, where the distance between centers of pits is 23 feet, and at the Angus shops of the Canadian Pacific, where the distance is 24 feet 9 inches.

In transverse shops, distance between pits naturally has no effect upon the width of the erecting bay. The governing factor determining the distance between pits is the same in both long and cross shops and depends upon the space required for workmen and for handling material, the location of work benches, the disposition of such parts of the locomotive as are not distributed to different departments and machines.

provision for storing cabs, and the use of portable machine tools on the erecting floor, etc.

The width of the bay in the cross shop is governed by the length of the largest locomotive likely to be repaired in the shop, the provision for an open passage way or aisle forward of the locomotives standing on the pits and of sufficient width to provide for handling boiler tubes in a manner that will not obstruct the passage way. The necessity for a bay wider than that to meet these requirements, depends upon the provision for the disposition of driving wheels. In some shops driving wheels are stored back of the engine to which they belong and on an extension of the pit and driving boxes are fitted to the axles while in this location. This is the practice of the Burnside shops of the Illinois Central Railroad, where the width of the bay between inner faces of crane columns is 74 feet 6 inches.

At the Collinwood shops of the Lake Shore and Michigan Southern Railway a comparatively narrow erecting bay is secured by a satisfactory provision for handling driving wheels. The tracks of the erecting pit extend into the adjacent bay and when wheels are removed they are rolled back of the engine into the heavy machine tool bay, where they are handled by the lighter crane, an arrangement which has the furter advantage of relieving the cranes over the erecting floor. Wheels are handled similarly at the McKees Rocks Shops of the Pittsburg and Lake Erie.

Sometimes engine trucks are repaired on the erecting pits in front of an engine, but this practice would not seem to justify its being a factor in widening the erecting bay to accommodate this work. It would seem more satisfactory to handle all truck work in a section reserved for this purpose, where it could be handled by a special gang repairing all trucks for the entire shop. Where this is not provided for, it would seem more satisfactory to repair the truck on the floor between the pits where it will not form an obstruction to movement up and down the shop and will not interfere with the erection of scaffolds and other provisions necessary in handling boiler tubes.

With cross shops the erecting bay is sometimes made wider than the requirement of the erecting department in order to provide for the location of a few heavy tools within the limits of the erecting bay where they can be served by the erecting floor crane. This practice is followed at the Danville shop of the Chicago and Eastern Illinois and to some extent at the Richmond Hill shop of the Long Island Railroad.

The greatest distance between crane columns in a longitudinal erecting bay, of which information is at hand, is in the shop of the Central Railroad of New Jersey at Elizabethport, N. J., where this distance is 79 feet 4 inches. The distance between centers of pits is 22 feet and the distance from centers of outside pits to crane columns is 17 feet 8 inches. This latter distance is greater at the Elizabethport shop than at the other shops, and therefore necessitates a wider erecting floor bay.

The more common distance from center of outside pit to inner face of crane column is between eleven and twelve feet. Assuming 11 feet 6 inches as representing general practice and that 22 feet between centers of pits provides ample space for ordinary working conditions, it would seem fair to draw the conclusion that the width of erecting bay between faces of crane columns for longitudinal shops is 67 feet.

By examining the available dimensions of several locomotive shops having cross pits it is found that the maximum width of bay between faces of crane columns is 74 feet 6 inches, at the Burnside shops of the Illinois Central. This is an extreme case and is hardly conclusive of desirable practice. Wheels are stored behind engines standing on the pits, and between ends of pits and the crane columns is a wide passage way or aisle which at one time contained a standard gauge track, since removed. At one end of the shop, a portion of this space has been used for the location of a large wheel lathe within range of the erecting floor crane.

While the minimum is represented by the Chicago Great Western shop at Oelwein, and the Wisconsin Central shop at Fond du Lac, where width of bay is 57 feet 4 inches and 57 feet 8 inches respectively, an approach to a very satisfactory width of bay seems to have been determined upon at Collinwood on the Lake Shore and Michigan Southern Railway where this distance is 64 feet 2 inches. At the McKees Rocks shop of the Pittsburg and Lake Erie very satisfactory results appear to be obtained with an erecting bay 60 feet 2 inches wide. The arrangement of erecting and machine bays at McKees Rocks is very similar to that at Collinwood, where there are two machine bays, both on the same side of the erecting bay.

It would seem then that a narrower locomotive erecting bay may be used to advantage with the transverse shop than with the longitudinal shop, though the difference is so small as hardly to be considered.

MACHINE BAY.

The practice of modern shops points to a custom of providing at least two machine tool bays. One bay is crane served and contains the majority of machines for heavy work, wheel lathes, tire boring mills, frame planers, slotters, drills, etc. The bay containing the heavy tools is naturally next to the erecting floor in order to minimize travel in delivery of material between erecting floor and machines.

The second bay usually contains lighter tools and is not often served by long distance traveling cranes. It is not unusual to find many machines in this bay served by traveling hoists or swinging jib cranes. The tool room and office are frequently placed in this bay.

In a number of modern shops the bay containing lighter tools is often entirely or partially covered by a gallery or balcony in order to enlarge the area of machine

tool space without increasing the ground area of the buildings as a whole. Such a balcony commonly contains machine tools for lightest service, such as brass work, light turret lathes, etc., and commonly the tin and copper smith departments.

AREA OF ERECTING FLOOR.

In cross locomotive shops the erecting floor area per pit varies in present shops of which information is available, from about 1,300 square feet to 2,288 square feet. This area at the St. Paul shop of the Omaha Railroad is 1,320 square feet; at Fond du Lac, 1,420; Reading, 1,523; Denver, 1,599; McKees Rocks, 1,598; Baring Cross, 1,500; Collinwood, 1,535; Sayre, 1,647; Oak Grove, 2,288. These figures are selected from large as well as small shops, and from old and new shops and indicate that the area of the erecting floor per pit does not vary according to the size of the shop, and while this area varies in different shops, it cannot be said either to have increased or decreased with the progress of time.

With longitudinal shops the area of erecting floor per pit varies from 1,667 square feet at Omaha, Union Pacific Railway to 2,000 square feet at Elizabethport, Central Railroad of New Jersey. There are so many shops in which the area of erecting floor per pit is about 1,700 square feet as to indicate that this ratio is satisfactory in long shops. The larger area noted at Elizabethport is due to the greater distance from outside pit to limits of floor than obtains in most shops.

At the Silvis shop of the Rock Island Railroad, which is arranged according to the herring bone plan, the area of erecting floor per pit is 1,910 square feet.

The number of peculiar governing conditions which enter as factors in determining the proportion between machine floor and erecting floor, renders difficult any attempt to formulate a rule governing this relationship. The relative proportions existing between these two departments and the demand for machine tool space generally felt at practically all shops, would indicate the necessity of a much larger area per pit for the machine floor than for the erecting floor. The figures representing the area of machine floor per pit are very similar to those representing the erecting floor, and vary from .85 to 1.5 of the area of the erecting floor per pit.

AREA OF MACHINE FLOOR.

Quotations from those shops just mentioned in connection with the erecting floor would indicate the trend in this connection. The machine floor area per erecting pit is as follows: St. Paul shops of Omaha Railroad, 1,426; Fond du Lac, 1,419; Reading, 2,123; Denver, 1,419; McKees Rocks, 2,340; Baring Cross, 1,365; Collinwood, 2,208; Sayre, 2,039; and Oak Grove, 1,294.

While none of the shops now in operation would warrant the conclusion, the experience of many shops for want of space would seem to justify a recommendation of machine floor area per pit equal to at least twice the erecting floor area per pit. The indications are that present erecting floor areas are sufficient to meet requirements. That greater machine floor space is required is evident at many shops. A certain mechanical official expressed the opinion that present railroad shops lead him to the conclusion that the general tendency is to provide machine tool space entirely too small for the erecting floor and his recommendation would be three to one. Such an opinion is shared by others as well.

By concentrating a large number of men around a locomotive to push erecting and boiler repair work, rapid progress can be made when the finished material is available. Unless the machine work and that of the sub-departments can be made to keep pace with or ahead of the erecting floor, it would seem uneconomical to use a large number of pits as storage spaces rather than working spaces.

Where the practice is followed of inspecting engines before they leave the divisions to which they belong for the purpose of ordering necessary material in advance and thus be prepared when the engines arrive at the main shop, it is possible to push forward a certain portion of the machine work. This provides another factor which commends the larger machine floor area.

There is a difference of opinion concerning the number of machine tools which should be provided per pit in a locomotive repair shop. The argument in favor of increasing the machine floor area naturally refers to an enlarged tool capacity. At the same time, however, the general reference to machine space includes space provided for the several sub-departments which are maintained within the limits of the machine floor.

RELATIVE AREAS OF ERECTING AND MACHINE FLOORS.

Existing shops are not sufficiently alike in all details to determine a definite opinion or to allow specific conclusions to be drawn. Though the more recently constructed shops are much larger than the older shops and are designed to handle the larger power of the present, the relative size of the machine floor as based on the size of the erecting floor is not much larger than in the older shops and there is as much variation among the new ones as among the old.

A selection of several examples shows that the ratio of the machine floor area to erecting floor area varies from .65 to 1.66. Referring now particularly to shops which may be considered among the old ones built at a time when engines now looked upon as light represented modern power, it is interesting to note that the area of the erecting shop at Oelwein is larger than the machine shop and that the ratio of machine floor to erecting floor is .65. At the West Burlington shop of the Chicago, Burlington & Quincy and at the Bloomington shop of the Chicago & Alton these floors are of the same size.

Among the older shops remodeled to meet the conditions of the present date practice, the ratio of machine floor to erecting floor is 1.48 at the Omaha shop of the Union Pacific, and 1.8 at the Chicago shops of the Chicago and Northwestern. Considering some of the new shops built since 1902 there is as much variation as among those previously considered. This ratio is .87 at the Silvis shop of the Chicago, Rock Island and Pacific; 1.00 at the Danville shop of the Chicago and East-

ern Illinois; 1.02 at the Indianapolis shop of the Big Four Railway now under construction; 1.42 at the Collinwood shop of the Lake Shore and Michigan Southern; 1.43 at the McKees Rocks shop of the Pittsburg and Lake Erie, and 1.5 at the Topeka shop of the Atchison, Topeka and Santa Fe.

While these figures show that it is coming to be appreciated that a larger machine floor area is necessary, they do not indicate this fact to the same extent as is evident from the additions being made to some present shops. In most cases this addition is being provided for by a balcony or second floor. However, at the Reading shop of the Philadelphia and Reading additional buildings are being erected in connection with those already erected. Where the original erecting bay contained 103,600 square feet and the orignal machine bay contained 44,400 square feet, 100,000 square feet have been added by extensions, now making the total area of the machine bay 144,400 square feet and providing a ratio of machine floor area to erecting floor area of 1.39.

FLOOR SPACE PER MACHINE.

Because of the irregular sizes and shapes of the ground plans of the various classes of machine tools and the difference in the nature of the work handled, it is practically impossible to assign a definite amount of space per machine, even in proportion to the area occupied by the machine itself, that will apply to all machines. It has been said that for each machine the floor space required for operator, proper handling of work, etc, is very nearly equal to twice the area occupied by the machine itself, the area occupied by a machine being considered as equal to the product of its extreme dimensions, and that the floor space required in aisle room and general passageway will be approximately equal to 25 per cent more than the space occupied by the machine.

It is impossible, however, to formulate a definite rule which might be considered at all practical for all machines because of the many varying conditions which govern not only the location of the machine but the space which must be provided around it. It would seem, therefore, that the most practical method of arranging the machine tool layout is the old-time drawing-board method with pieces of paper cut to the same scale as the drawing of the shop floor plan. In following this each machine may be provided for individually according to the group in which it belongs and according to the class of work to be handled by the particular machine.

AISLE SPACE.

The provision for the movement and delivery of material is a very important factor in arranging the machine tool layout. Those shops which are operated most successfully are so arranged as to maintain an aisle extending the full length of each bay as an avenue for delivery, with transverse aisles at intervals, for transportation across the machine bay, to the erecting bay, or leading to a door connecting with the shop yard. Where sufficient space is not provided for standing material around each machine, such aisle space is infringed upon to the extent of seriously obstructing and interfering with distribution of material.

GROUPING OF MACHINES.

The machine tool layout and arrangement of sub-departments of new shops and progressive changes in the older ones, together with the now more general practice of gang work, shows a keener appreciation of economy in working methods and increase in output obtained by grouping and specializing all work of the same class. This applies to the systematic grouping of machines in order that, after an engine has been stripped, the parts cleaned and delivered to a gang or sub-department, the various parts will require the least possible amount of movement while undergoing repair.

An example of such organization is manifest in connection with work on driving wheels, in which is included tires, journals, hub plates, driving box work, eccentrics, straps, etc. By locating near together the several sub-departments in which all such repair work is done, the movement necessary in advancing from one stage to the next is reduced to a minimum. It is now very common practice to pursue all wheel work on the machine floor, so that when a pair of driving wheels is returned to the erecting floor there is little more to be done by the floor gang beyond putting up the binders, shoes and wedges and connecting the motion work.

Therefore, by grouping machines and all necessary facilities the movement of wheels is reduced. This includes such location of large and small boring mills, wheel lathes, quartering machine. driving box equipment, tire setting equipment, etc., that there will be the smallest possible amount of movement of the several parts concerned after a pair of wheels has been delivered to the machine floor.

In both machine tool bays good practice indicates the use of swinging jib cranes and traveling hoists to facilitate handling material in sub-departments. For instance the movement of driving boxes to and from benches, planers, boring mill, drill, etc., and in laying out equipment provision is made to group the several machines in order to serve a specific sub-department, and thus minimize the travel of material.

In the heavier machine tool bay good practice is to serve individual machines and groups of machines by swinging jib cranes or hoists in order to relieve the traveling cranes. Planers are sometimes placed in bays not served by cranes, yet they are so situated that their tables may be run out under the crane of the next bay, so that they are practically crane served. This is noticeable at the Terminal Railroad Association of St. Louis shop at East St. Louis; McKees Rocks shop of the Pittsburg and Lake Erie; at the Danville shop of the Chicago and Eastern Illinois, and others.

In the Sayre shop, practically all machine tool equipment is under crane service. This is an excellent feature. However, the departments for rod work, motion work, air brake lubricators, gauges, etc., are under the gallery, and while this location is not dark in the Sayre shop, such a location as a general proposition does not seem

preferable in view of the nature of the work required at the benches.

At the Angus shops of the Canadian Pacific, there are two machine bays, both on the same side of the erecting floor. The wider bay, next to the erecting bay, is crane served throughout and contains the larger machine tools. The benches for motion work, rod work, air brake repairs, etc., are located in this bay. The benches are placed in the same vicinity, so that these several departments are practically grouped, and this arrangement commends itself as superior to placing benches for such work along walls, in corners, or in out of the way places.

Above the outer bay is a gallery in which the tin and coppersmith departments are located. The bay beneath the gallery is not served by a traveling crane, except in a small section, where engine truck repairs are made. Machine tools for lighter work are located in this bay.

The arrangement of machine tools in the Angus locomotive shop is representative of systematic grouping in order to reduce the cost of repairs and to increase the output of the shop. The machines are located in large groups, each arranged for a certain class of work. The machines for wheel work are located at the end of the shop nearer the midway. There is a wheel storage track beside the central supply track. Adjacent to this track on the erecting side are five wheel lathes and the quartering machines. The machine shop traveling crane covers this space and is used for placing the wheels in and out of machines. The wheel press is located at the end of the building in line with the lathes. This press is served by a jib crane attached to a steel column, and has a small electric chain hoist. The open space in front of the press is used for the setting. All the machines for driving and truck wheels, such as boring mills, axle lathes, milling machines, etc., are located on the other side of the central supply track.

The next group of machines is for cylinders, trucks and driving box fittings. There is a clear floor space for some distance, with lateral tracks and numerous jib cranes, supporting air hoists used for repairing engine trucks. The large cylinder planer and cylinder boring machine are placed in line with the wheel lathes and are served by the shop crane. Across the track are located machines for driving box fittings. The cleaning vats are placed in an addition just outside of the machine shop wall.

The next machines are the large frame planer, triple head frame slotter and multiple spindle frame drill. Across the track from these are machines for crosshead and piston work, as well as machines for lighter framework. The next group of machines consists of planers, slotters, milling machines, etc., for rod work. There are also a number of benches for fitting in this group. There are a large number of jib cranes in this section. The next group of machines is used for valve motion and general machine shop work. Following these are the machines and floor space for brake and spring work, scale repairs, air brake work and steampipe fitting.

The rest of the main floor of the machine side is taken up with machines for boiler work. The first part has the flue department, with the regulation machines and furnaces, and a chain wet flue rattler. The latter machine is of interest on account of the small amount of time required in changing flues. This work has been accomplished in six minutes. The other boiler shop machines are arranged on either side of the central track to the end of the building and include a number of hydraulic punches and shears, as well as those driven by motors. This section has a large number of jib cranes with chain hoists, driven by air motors. The hydraulic pump and accumulator are located in the corner on this side of the building. The hydraulic riveters, of which there are two, one with 17 ft. gap and one of 6, are located at this end on the erecting side, where fitting up boilers and tank work is done.

In the gallery are located the small machines of all kinds for light work, including a tin shop, bolt department, brass work, tool work, etc.

STORAGE OF DISMANTLED PARTS.

Provision for the storage of dismantled locomotive parts which are not delivered to special repair departments or to some of the various machines is a very important consideration. The practice of providing pits beneath the floor, with movable covers, for the storage of such parts has generally been looked upon with disapproval, and this method is now seldom installed.

Several shops have used a specially designed rack on which the parts are stored while an engine is in the shop, and this arrangement has proved very satisfactory. In some instances a plan adopted provides for storing the cabs on this rack, supported by specially designed arms. This arrangement has not proved successful, and it would seem more expedient to store the cabs outside of the shop and preferably in a space served by an outdoor crane in order that they may be handled at minimum expense.

At the Louisville shop of the Louisville & Nashville Railway provision for dismantled parts is made in a very satisfactory manner by a platform supported by the columns between the erecting and machine bays. This platform extends from one column to the next throughout the length of the erecting floor and is carried at such height that it does not interfere with transportation or passage between the two bays. By storing these parts above the floor they are kept out of the way, and not only located where they are not susceptible to damage, but are also placed where they will offer no obstruction on the floor.

In addition to this platform, lockers are placed by each post and all small material, boiler fittings, cab appliances, etc., are placed in these lockers until such time as they are replaced on the locomotive from which they were removed. As soon as an engine is dismantled, all parts requiring repairs are distributed to the various departments. After repairs have been made these parts are

returned to the erecting floor and stored on the platform or in the lockers and are not allowed to obstruct any part of the shop. The platform is so situated as to be served by the erecting floor crane. Those parts not requiring repairs, such as brake rods, beams and levers, hangers, column brackets, pipes, hand rails, casings, jackets, etc., are stored on the platform as soon as the locomotive is dismantled.

SANITARY REQUIREMENTS.

In considering the sanitary requirements of a shop a number of peculiar features enter into the determination as to the most desirable facilities to be provided for the convenience and comfort of the men. While the statement in this connection might seem extraordinary, the amount of facilities required depends, like a number of other features in shop design, upon the organization.

The facilities provided in modern shops vary as to the number of each item provided per 100 men. From information gathered at several shops it is found that the number of wash basins per 100 men varies from 7 to 33; closets, 8 to 32, and urinals, 3 to 20. While these figures vary to such an extent as to be hardly sufficient to warrant conclusions, the following would seem to be a reasonable provision per 100 men: 33 wash basins, 15 closets and 10 urinals. Many of the men do not stop to wash up carefully before leaving the shop, and it is fair to assume that at least three men can use the same basin. It is preferable to provide ample closet and urinal accommodations rather than not enough. It has been said that the introdnction of piece work at a certain shop reduced the necessary closet facilities about 50 per cent.

The experience of a number of shops in which the best kind of plumbing was installed would suggest the query as to whether such facilities are thoroughly appreciated. It is believed that the men are better satisfied with good and healthful ventilation than with elaborate fixtures.

Such thorough ventilation may be provided with modern equipment that many shop managers approve of locating all toilet facilities within the building. This not only removes the necessity of men going out of the building during working hours and provides against their going out of doors ill clad during cold and stormy weather, but further removes an opportunity for them to go beyond the observation of the foreman.

Some officials approve of placing a number of urinals at various places of convenience about the shop where they may be screened from view. This arrangement has the advantage of providing accessible conveniences without the necessity of a long walk where the shop is large.

In the locomotive shop building at Silvis there are four lavatories so disposed as to serve four territories of about equal areas in the shop. The lavatories are located on balconies. At the Angus shop the lavatory is in a wing of the building, or lean to. At the Collinwood shop it is on the ground level, in a position near the center of the shop. At McKees Rocks it is on a balcony.

The most comfortable arrangement of lockers is the provision of one locker for each man, though not infrequently two men occupy the same locker. Best practice indicates the more general use of metal lockers so constructed as to permit a free circulation of air and to provide for easy inspection to guard against the accumulation of inflammable material.

At Silvis the lockers are grouped beneath the balconies in which the lavatories are located. These are placed within an enclosure and access thereto may be had during certain hours only. At other times it is necessary to secure admission from the foreman. At Collinwood the locker room is on a balcony above the lavatory. At Sayre the locker room and toilet facilities are on the balcony, and it is found that the men are not favorably inclined to such a location for the lockers.

In a few shops the toilet facilities include shower baths.

The new shops of the Brown Hoisting Machinery Company have been equipped with shop toilets of new design which seem practicable and serviceable. The design comprises a series of stalls, or compartments, separated by concrete steel partitions of the Ferroinclave construction, attached to light angle supports covered by one concrete steel hood. This hood is also of Ferroinclave construction and runs to an apex at about an equidistance from either end partition, and which apex is a ventilating pipe. With the exception of the two ends, the partitions do not extend up to the hood, thus giving sufficient air circulation. The hood extends out over the doors.

The doors are hung from light angles, which extend across the partitions. These doors consist of steel plates rolled in the form of semi-cylindrical shells, and are hung from the top instead of from the side, being so adjusted that in rotating on rollers they describe the path of a cylindrical shell about its vertical axis.

Among the advantages claimed for the design are: A saving of space (practically three feet being saved by this door) over the ordinary side hinged style, in a sanitary way, the excellent hood or ventilating system, taking away all odors, and the concrete walls allowing easy cleaning with a hose. The interior is at all times closed to the outside view, thereby making it practicable to erect the same at points in a building that would be too exposed for the types of closets in ordinary use. It can readily be seen by the door whether a closet is or is not occupied. A closet cannot be occupied without the door being out. This fact, together with the lack of light and the partitions, is the means of a great saving in time, in that it eliminates the usual causes for the men loafing.

SYSTEMS OF ELECTRICAL DISTRIBUTION.

The systems of motor driving now on the market providing speed variations electrically have been worked out with a great deal of ingenuity, and all of them have some points in their favor for certain classes of service.

The problem before the railroad repair shop, however, is peculiar, and has certain features which are not common to any other line of manufacture. The success or failure of any system in a railroad repair shop will depend largely upon the simplicity and reliability of the

system for obtaining a given result. Railroad repair work, in general, is not susceptible to such great refinement as are certain lines of manufacture which duplicate standard parts indefinitely, and for this reason a system of distribution adapted to the needs of the repair shop must be flexible.

It is also important that, as far as possible, the system be capable of sub-division, in so far as the generating units are concerned, due to the fact that considerable overtime work is necessary, and at such times it is desirable to shut down parts of the generating equipment, operating only such machines as necessary.

There was a time, a number of years ago, when the railroad shop was extremely conservative in the matter of taking up new ideas, and was probably working to less advantage than any manufacturing establishment, for the reason that railroad repair work is practically devoid of competition. Some of the railroads have been extremely progressive in adopting new methods of production as applied to repair work, and they have virtually set a pace which must eventually be followed by the others. This will be more true as reliable reports of the better results obtained by the use of modern machinery and methods become public.

Second only in importance to the rapid production of work is the economy and reliability of the installation. Economy in operation means a reduction in the capacity of the engines and boilers operated in the power plant, and should also logically include the cost of maintenance and repairs to the apparatus installed.

Third in importance is the question of cost. Before any particular system is installed, complete costs should be obtained, including not only the cost of the machinery proper, but also the cost of wiring and special fixtures which in many cases constitutes a very appreciable percentage of the total cost of the installation.

Next in importance is the matter of simplicity. The average mechanic to-day is not a skilled electrician, and the installation of apparatus which is so simple that it may be maintained by the operator will save much time on the part of the regular repair man, who is usually busy with more important duties than the maintenance of individual motors throughout the plant.

In many cases individual drive will be found desirable, particularly for the larger machines, such as wheel lathes, frame planers and slotters, boring mills, axle and crank pin lathes, and in general machines doing comparatively heavy work. For the lighter machines, the group drive seems to be preferable, chiefly on account of its smaller cost. It is not the intention to discuss the relative merits of the individual and group drive to any considerable length. It is deemed desirable, however, to call attention to the fact that the individually driven tool is capable of being used independently of the rest of the equipment, and that, when so operated, it calls upon the power plant for only the power necessary to supply the driving motor. In making an installation it is usually possible to arrange for such a combination of group and individual drive that, when it becomes necessary to work part of the shop equipment overtime, there will be operated, as a rule, only the tools required for the work in hand.

Broadly speaking, the various systems of electric driving which admit of speed variation applicable to machine shop work are as follows:

(1) Multi-voltage systems;

(2) Double commutator systems;

(3) Systems in which the speed regulation is obtained by means of field control on one or two voltages; that is, a 2-wire single-voltage system or a balanced-voltage 3-wire system.

MULTI-VOLTAGE SYSTEM.

Considering first the multi-voltage system, it may be stated that this method, in general, consists of a number of wires between which various voltages may be obtained, the differences in voltages being produced by means of a series of boosters, or motor-generator sets, in combination with the main generator. This system originally involved the use of the following voltages: 40, 80, 120, 160, 200 and 240, and required for its distribution four wires. For the reason that the horsepower output in a given motor is practically proportional to the horsepower input, it is evident that the lower voltages, in order to transmit a definite horsepower, the current must be quite large as compared with that required at the higher voltages. This being the case, considerably larger conductors will be required for a given horsepower transmitted at the lower voltage than would be the case were the voltage maintained at a higher value. For this reason, as stated elsewhere, it is essential that the cost of the wiring be carefully considered before the multi-voltage system is adopted.

One of the principal characteristics of the multi-voltage system is due to the fact that the horsepower which may be developed by a motor increases directly with the voltage impressed on the armature terminals, the field strength remaining constant. This can be stated in another way, which may tend to bring out some interesting information relative to motors operating on the multi-voltage systems, under the present scheme of normal ratings adopted by the manufacturers of multi-voltage apparatus, the horsepower delivered by the motor decreases directly with the decrease in voltage from about 120 volts to whatever voltage may be called the starting voltage of the system. Since, in machine tool work, approximately constant output is demanded of the motor, it can be readily seen that, as the capacity of the motor decreases, the amount of the metal which can be removed decreases, and with it the value of the extreme range of speed variation; for speed variation in itself is of no value; it must be accompanied by the ability to operate the driven tool at its maximum capacity at all points within the limits of speed range claimed for the multi-voltage advocates, making approximately 1 to 3 and 1 to 8 in speed variation which are made by the system. This condition will qualify the claims of 1 to 10 the effective working range, unless the motor is abnormally large, and but a fraction of its possible output

is utilized at the higher speeds. It is essential that the purchaser of a variable speed motor obtain a continuous horsepower output over the entire speed range claimed for the motor, in order that he may be fully informed as to its suitability for the work in hand.

One of the advocates of the multi-voltage system has made the statement that 1 to 3 variation in speed is sufficient for machines requiring a constant horsepower output, such as lathes, boring mills, milling machinery, etc. It should be noted that this is the maximum speed range possible with the multi-voltage system, using as a minimum voltage about 120 volts, which is the lowest commercial voltage at which power may be generated, distributed and utilized without making the size of feeders abnormally large. For machines involving a reciprocating motion, such as planers, slotters, etc., the same manufacturer has made the statement that the horsepower increases directly with the speed. This statement is incorrect, for the reason that if the machine tool be worked anywhere near its capacity, the horsepower at the tool actually increases with a decrease in speed, within the working limit. Adding to this the increase due to the greater friction of the machine itself, it will be found that on machines involving reciprocating motion the horsepower required at the varying speeds will not fluctuate greatly. For this reason it is evident that the multi-voltage system as applied to machine tools should only be used throughout such a range of speeds as will permit of constant horsepower being obtained at every speed. In fact, this point is now realized by the manufacturers of multi-voltage apparatus to such an extent that one of them has made the statement that the lower voltages are to be used "for starting and light cuts only." It is a remarkable fact that the advocates of the multi-voltage systems are gradually abandoning the lower voltages and tending toward a single, or at most, two voltages in combination with field control, with a corresponding decrease in the total variable speed range, and a corresponding increase in the range of speed permitting constant horsepower to be taken from the motor. Thus one manufacturer has abandoned 40 and 80 volts, while the second has abandoned 60 and 80 volts and is now using 90 volts as a minimum. In both of these systems the intermediate speeds are obtained by means of field control—thus tacitly approving of this method of obtaining speed variation.

The controller used in connection with the multi-voltage system must handle a number of voltages, in addition to the field current, and is of necessity more complicated than would be the case were the machine operated on a single or two voltages.

DOUBLE COMMUTATOR MOTORS.

The use of double commutator motors has been limited, more or less, to the operation of printing presses, in which service the horsepower varies approximately as the speed; in other words, the minimum speed requires the minimum horsepower.

The construction of the double commutator motor involves the use of one commutator on each end of the armature. The armature windings connected to these commutators may comprise either the same number of turns or a different number of turns, the principle of operation remaining the same. As the speed of a motor on constant voltage depends upon the number of turns in series in the armature, it is evident that by connecting both of these commutators in series, the number of armature turns may be increased, thereby producing a slow speed. As it is desired to increase the speed of the motor, one of the sets of windings in series is cut out, and, on one system, the speed is further increased by connecting the two commutators, so that the two sets of armature windings having a different number of turns oppose one another. The charactersistics of the double commutator motor may be fairly represented by the performance of an ordinary motor on the multi-voltage system, in which the horsepower increases approximately with the increase in speed, but as a rule the controller used in connection with the double commutator machine is extremely cumbersome on account of the numerous functions which it has to perform, that is, connecting the commutators in series, connecting them to the circuit individually, and finally connecting them in parallel, and, in addition to this, the field current must also be varied for the purpose of obtaining the intermediate steps in speed.

One of the principal objections to the double commutator motor for machine tool driving is that, where the double commutator motor is used, the overhang from the center of the motor frame to the point of attachment of the pinion, if the machine be gear driven, is considerably greater than would be involved were the commutator, and consequently the extension of the bracket on the pinion end, absent. The importance of a rigid frame, with the point of application of the pinion for gear driving as close to the point of support at the base of the motor as possible (this distance being measured perpendicularly to the shaft), cannot be overestimated. Gears have imposed upon the shafts, bearings and end brackets of motors much more severe conditions than they ever encountered when belt drive was used, and this is a feature which is well worthy of careful consideration in installing motors for individual drive.

A second objection to the double commutator motor is the duplication of perishable parts, such as the commutator and brushes. While the renewal of brushes in a properly designed and well constructed direct current motor should not of necessity be very frequent, at the same time the double commutator motor doubles the opportunity for wear. The rear brushes, that is, the brushes on the pinion end, will very frequently be found more or less inaccessible, for the reason that the pinion end of the motor is frequently crowded closely into the machine tool, and it is the opinion of one of the largest machine tool builders in the country that this constitutes one of the principal objections to the use of a motor of this character.

This system has without question some advantages over the straight multi-voltage system, but the fact that double commutator machines have been built for a num-

ber of years, and that these machines have not come into general use, indicates possibly better than any other argument the feeling of machine tool builders and manufacturers as regards this system.

THE ALTERNATING CURRENT SYSTEM.

Because of the ease with which alternating current may be transformed either in voltage or phase it presents many advantages over any other system of distribution. Long distance transmission may be effectively accomplished by means of the alternating current.

The alternating current motor is peculiarly adapted to severe service, and for driving line shafting, or individual machines, the speed of which may be changed by mechanical devices, gives all the advantages obtained by the use of electrical distribution in general, together with a motor which is the acme of simplicity so far as mechanical construction is concerned. The absence of commutator and brushes contribute to produce a motor on which the maintenance is extremely small, and many large installations are now operating by means of alternating current motors exclusively.

The alternating current motors may be used in connection with direct current motors, both alternating current and direct current being obtained fom a single generator, or from rotary converters, and it would not be surprising if the mixed systems became quite common for industrial and railroad plants. In the railroad shop installations now in service the main generators are of the polyphase alternating current type, direct current being obtained by means of rotary converters of the 3-wire even voltage type. These rotaries possess all of the advantages of the 3-wire generators, giving a 3-wire even voltage circuit from a single machine, using highly efficient stationary balancing coils in place of the wasteful motor-generator balancing units.

SYSTEMS IN WHICH SPEED VARIATION IS OBTAINED BY FIELD CONTROL.

Referring now to the third general division, that is, systems in which the speed variations is obtained by field control: There are on the market to-day a number of manufacturers advocating this means of speed variation. The system involves the insertion of resistance in the shunt field of the motor, and while the general scheme used by different manufacturers is the same, the details have been worked out differently by the various companies building machines of this class. One manufacturer uses a so-called reaction winding, the purpose of which is to neutralize the armature reaction. This method has in its favor the possibility of considerable range in speed on a single voltage, while on the other hand, it involves considerable complication in construction, as compared with the ordinary motor.

A further objection to this construction is that this reaction winding interposes in the armature circuit considerable resistance, and the introduction of resistance in the armature circuit has always been accompanied by undesirable results, so far as machine totol driving is concerned. The greater the resistance in the armature circuit, the greater will be the drop in speed between no load and full load, and it is evident that on many classes of work, such, for example, work involving intermittent cuts, a tool would very quickly be ruined.

It is possible on a machine of this type, by giving the brushes back lead, to produce a certain demagnetizing armature reaction which will counteract the resistance drop in the reaction winding at normal speeds. This, however, is a dangerous procedure, for the reason that when the higher speeds are reached the field is extremely weak and there is a possibility of the field being reversed, in which case the motor will draw an abnormally heavy current, and in all probability be burned out, provided the fuses or other protective devices do not open the circuit promptly.

It is claimed by the manufacturers of this motor that a range of speed as high as 1 to 6 on single voltage is entirely possible, the horsepower remaining constant throughout the whole speed range. While it is not the intention to go into the matter of the practical speed range on an electric motor for machine tool driving, it is sufficient to say, however, that the size and weight of a variable speed motor of given output, operating on any system, whether it be multi-voltage or field control, will increase as the minimum speed of the motor decreases. When a range of speed of 1 to 6 is obtained the minimum speed must be kept fairly low for mechanical reasons, and there is some question as to whether speed range of 1 to 6 on a single voltage represents the best practice.

A properly designed shunt or compound wound motor may for machine tool service be operated throughout a speed range of 1 to 2 on a single voltage by field control without the use of reaction windings, or in fact any device especially intended to minimize the sparking at the commutator. This system presents the simplest variable speed mechanism yet developed for moderate speed ranges. The motor is a standard motor; the number of wires is reduced to a minimum and the speed range is sufficient to eliminate a considerable amount of intermediate gearing, the coarser increments being obtained by gears, frequently in combination with clutches, or belts and cone pulleys. With this range of speed, at a given output, a motor of normal size may be employed with a corresponding decrease in the cost as compared with the wider speed ranges, and the generating outfit presents the simplest possible solution for a power and lighting distribution plant.

Some of the machine tool builders of to-day have adopted a speed range of 1 to 2 as the standard, claiming thereby that they can produce motor driven machines cheaper, using a 1 to 2 motor with the decreased amount of gearing, than would be possible were a constant speed motor used, and that the machine tool may be produced cheaper than would be the case were a greater range obtained electrically with a decreased amount of gearing.

This system has been consistently advocated by one of the large manufacturing companies, and there are to-day many installations in which motors having a speed range of 1 to 2 on a single voltage are operating with

entire satisfaction. The horsepower output is constant throughout the whole speed range and the commutation is all that could be desired. The controller has but one armature voltage to handle, while the field current is comparatively small and may be handled without difficulty.

A natural extension of this system leads to the 3-wire, 2-voltage system, using equal voltages on either side of the neutral wire and eliminating the rotating balancing set. The rotating balancing set, while a comparatively small machine, cannot be particularly efficient, and operating as it does all day, its losses in the course of a year represent an appreciable amount. Its elimination, aside from the compilation which it introduces into a system is, therefore, desirable on the ground of economy. On the 3-wire system, 120 and 240 volts are available at the motors, and, because of the fact that the speed of the motor varies approximately as the voltage applied to its terminals, it is evident that on the 120 volts a speed range of 1 to 2 by field control may be obtained; that after the motor has reached the highest speed on 120 volts, its armature may be thrown on 240 volts, and a further speed range of 1 to 2 may be obtained, giving a total range of 1 to 4 The system of distribution used in the Edison Three-Wire system, which involves a minimum amount of copper for the transmission of a given horsepower, and the controller handles but two voltages in addition to the field current. By decreasing the minimum speed, with the consequent increase in the size of the motor, a greater speed range than 1 to 4 may be obtained; it is questionable, however, whether a greater speed range is economical for any class of machine tool work. Under the ratings given by the Westinghouse Electric & Manufacturing Company the horsepower which may be obtained from a motor operated on the 3-wire 2-voltage system is constant throughout the whole speed range. The application of motors operated on the 3-wire system to the driving of all classes of machine tools requiring variable speed gives increments in speed between the successive steps of the controller of about 12 per cent, which is considered fine enough for even the most modern practice involving the use of high speed steels and machine tools adapted to their use.

For group driving, so-called, constant speed motors may be operated from the 240 volt circuit obtainable when a 3-wire generator is used, but it should be noted in this connection that these motors are capable of a certain amount of speed variation by means of rheostats placed in their fields; for example, on certain sizes as much as 50 per cent variation in speed may be obtained; that is, the line shaft may be speeded up 50 per cent merely by the insertion of a rheostat in the field of the driving motor. With the rapid change in manufacturing conditions, such as the introduction of high speed steels, it is frequently a matter of prime importance that the speed of the line shaft may be increased by small increments from time to time, thereby speeding up the driven machinery. This method has been used to advantage, and the production has been known to increase in spite of the opposition of the various machine tool operators.

This system adapts itself well to illuminating purposes, the lights, standard 110-120 volt lamps, being operated between the neutral and either outside wire of the 3-wire circuit. By the use of the 3-wire circuit it is possible to so balance the motors on either side of the neutral when running on the lower voltage, that the quantity of current flowing through the neutral wire will be a minimum; if the motors were so distributed as to draw exactly the same amount of current from either side of the 3-wire system, the neutral wire would carry no current whatever. This condition is, of course, ideal, but can be approximated very much more closely with the 3-wire balanced system than is possible with any of the so-called multi-voltage systems.

ELECTRICAL DISTRIBUTION AT ANGUS.

There are three alternating-current and one direct-current circuits from the power house entering the machine shop. Each circuit comes to a large distributing board, from which circuits are distributed in the shop. Each of these circuits serve approximately 100 h. p. of motor capacity. The leads are taken from the distributing board, which is located in the gallery, above and outside the machine gallery, by three heavy insulated wires, carried on porcelain insulators along the roof trusses. The motor connections are made directly to these leads at the most convenient point. On each lead, just before the motor connection is taken off, is located an oil circuit breaker in a convenient position. There are no fuses, switches or other instruments in this circuit up to this breaker. The leads to the motors are carried through piping down the posts or walk to the starting box of the motor. This starting box is arranged in the form of a street railway controller, and each notch cuts out resistance as the motor gains in speed. There is a no-voltage release at each oil circuit breaker.

The direct current machines, of which there are comparatively few, are taken from a circuit running the full length of the building, at the nearest available point. They have variable speed controllers and circuit breakers located on each machine. All crane motors are connected to this circuit.

The lighting circuits are taken from the three-phase line through transformers to the lighting points. The transformers are arranged in pairs, one being connected to wires 1 and 2, and the other to wires 2 and 3. These transformers change the voltage from 550 volts to 110 volts. The light distributing boards, or panels, contain two copper buss bars, from which the several lighting circuits are carried through fuses and switches. Each of these small circuits carries not more than one enclosed arc or 12 incandescent lights. There are 15 transformers in the locomotive shop and 29 lighting panels. The lighting in the erecting shop is mostly by arcs hung from the roof trusses and with incandescents along the side walls, while that in the machine shop is practically by incandescent lights. There are plug receptacles located at short distances in all pits and along the posts, as

well as at benches and any other place where they may possibly be needed.

NUMBER OF MACHINE TOOLS.

The peculiar local governing conditions affecting the operation of each shop, together with the fact that most shops do a certain amount of manufacturing work not only for the immediate plant, but also for various plants along the line, render it almost impossible to present a list of tools which will provide for any given or individual shop chosen at random. Consideration must be given to the kind and class of repairs necessary owing to the peculiar conditions of the road, or the section of the road, on which the locomotives to be maintained are operated. Other conditions necessarily provided for are special defects in design, such as weak frames, cylinders and other special parts.

Another consideration is the amount of manufactured material carried in stock. It is believed that some roads are inclined to force the amount of material in stock, especially manufactured material, to too low a point.

An important factor in determining the number of machine tools in the locomotive shop is the question of standard and special machinery. Where parts of locomotives are well standardized, more special machinery may be utilized, which will increase the output of the shop.

An opinion prevails that present locomotive shops would be capable of a greater output and hold locomotives out of service for a shorter period of time during repairs, if the number of machine tools per locomotive pit was increased. For this reason from 8 to 10 machines per pit have been advocated. However, the ratio of from 6 to 8 machine tools per pit is more nearly representative of the equipment in existing shops most liberally provided and many shops are operated with 5 or 6 machines per pit.

It should be explained that the following tables are acknowledged to indicate ratios of machine tools per pit more liberal than actually to be found in most existing shops. The various conditions effecting locomotive repairs in different localities necessarily influence the proportions of the several types of tools. It is, therefore, impossible to produce a table from which a list of tools could be selected without modification to suit local conditions. In placing a new shop in operation it is customary to install but a portion of the machine tool equipment planned for and to add to the equipment as the shop becomes organized. In most instances the final requirements have surpassed the original plans.

Percentage of total number of machine tools for each of the various types:

Turning tools	50
Cutting tools	25
Drilling tools	11
Grinding tools	7
Miscellaneous tools	7
Total	100

Number of machine tools of each class per pit:

Lathes	3 11-12	3.925
Boring Mills	7/8	.875
Planers	1	1.00
Shapers	1/2	.5
Slotters	11-24	.458
Millers	3/8	.375
Drills	1 1-12	1.083
Grinders	2-3	.666
Miscellaneous	17-24	.708
Total		9.590

The conditions surrounding boiler work are such that it is even more impracticable to select a list of machine tools which will meet the requirements of any given boiler shop, than prevails in connection with the general machine tool equipment. There are many of the larger machines which are required singly by a locomotive shop maintaining general boiler repairs and the numbers of such machines per so many pits vary according to wide limits only.

For this reason the following list of the principal machine tools for the boiler shop has been selected, based on the requirements of a shop containing 24 or 30 erecting pits, and it is understood that the smaller or special tools should be added according to requirements of local conditions:

List of principal machine tools for boiler shop serving 24 or 30 locomotive erecting pits:

Rotary splitting shear.
No. 10 milling machine.
36-inch vertical drill.
Staybolt drill.
Staybolt cutter.
72-inch radial drill.
Hydraulic accumulator.
Hydraulic riveter.
Flange fire.
120-inch flange clamp.
Single punch, ¾-inch plate and 36-inch throat.
Multiple punch.
120-inch flange clamp.
Sectional hydraulic flange press.
Annealing furnace.
Flange punch.
Plate bending roller. (Large, 16 ft. long.)
Plate bending roller. (Small.)
72-inch punch—72-inch shears.
Plate planer.
Multiple drill.
Cold saw.
Angle shears.
Punch—1½-inch holes, 1-inch plate.
Total, 24 tools.

Machine Tool Equipment for the Locomotive Shop

MACHINE TOOLS FOR 1, 12, 15, 24, 48 ERECTING SHOP PITS.

	Machines for 1 pit	Machines for 12 pits	Machines for 15 pits	Machines for 24 pits	Machines for 48 pits
Lathes	3.925	47	60	94	188
Boring Mills	.875	10	14	21	42
Planers	1.00	12	15	24	48
Shapers	.5	6	8	12	24
Slotters	.458	6	7	11	22
Millers	.375	5	6	9	18
Drills	1.083	13	16	26	52
Grinders	.666	8	9	16	32
Miscellaneous	.708	9	10	17	34
	9.590	116	145	230	460

MACHINE TOOLS FOR 15 ERECTING PITS.

LATHES.

90-inch wheel lathe for turning tires	1
100-wheel lathe for turning tires	1
Quartering machine, 34-inch throw	1
42-inch lathes	2
36-inch lathes	4
30-inch lathes	5
24-inch lathes	6
20-inch lathes	7
18-inch lathes	12
16-inch lathes	12
2-inch by 24-inch turret lathes	2
2½-inch by 24-inch turret lathe	1
4¾-inch by 24-inch turret lathes	2
6-inch turret lathe	1
Special bolt turning machine	1
Cylinder lathe	1
Double axle lathe	1
Total	60

BORING MILLS.

96-inch boring mill	1
84-inch boring mill	1
72-inch boring mill	1
62-inch boring mill	1
51-inch boring mills	3
42-inch boring mills	2
Double rod boring machine	1
3-spindle cylinder borer	1
60-inch horizontal boring mills	2
36-inch boring mill turret	1
Total	14

PLANERS.

72-inch by 84-inch by 12-foot cylinder planer	1
72-inch by 72-inch by 36-foot frame planer	1
60-inch by 60-inch by 18-foot planer	1
48-inch by 48-inch by 10-foot planers	4
36-inch by 36-inch by 10-foot planers	6
30-inch by 30-inch by 8-foot planers	2
Total	15

SHAPERS.

18-inch double head shapers	3
16-inch stroke shapers	3
14-inch stroke shapers	2
Total	8

SLOTTERS.

Double head frame slotter	1
18-inch slotters	2
16-inch slotter	1
14-inch slotters	2
12-inch slotter	1
Total	7

MILLERS.

Vertical millers	2
Universal miller	1
Universal milling machine—tool room	1
Horizontal miller—tool room	1
Heavy horizontal miller	1
Total	6

DRILLS.

72-inch Universal radial drill	1
72-inch radial	1
3-spindle frame drill	1
60-inch radial drill presses	5
36-inch vertical drills	3
24-inch vertical drills	2
Drill centering machine	1
Total	14

GRINDERS.

Universal grinder	1
72-inch guide bar grinder	1
Universal tool grinder	1
Drill grinders	2
Piston rod grinder	1
Horizontal grinders	4
Total	10

MISCELLANEOUS.

400-ton wheel press	1
Pipe cutters	2
3½-inch single head bolt cutter	1
2-inch double head bolt cutter	1
1½-inch double head bolt cutter	1
Tool dresser furnace	1
Tool dresser trip hammer	1
Press for driving boxes and rod bearings	1
Universal cold saw	1
Grind stones	2
Total	12

MACHINE TOOLS FOR 24 ERECTING PITS.

LATHES.

Quartering machine, 34-inch throw	1
90-inch wheel lathe for turning tires	1
100-inch wheel lathe for turning tires	1
42 inch lathes	2
36 inch lathes	6
30 inch lathes	8
24 inch lathes	10
20 inch lathes	12
18 inch lathes	20
16 inch lathes	20
2 inch x 24 inch turret lathes	2
2½ inch x 24 inch turret lathes	2
4¾ inch x 24 inch turret lathes	3
6 inch turret lathe	1
Specia bolt turning machine	1

Cylinder lathes	2
Double axle lathes	2
	94

BORING MILLS.

96-inch boring mill	1
84-inch boring mill	1
72-inch boring mills	2
51-inch boring mills	6
42-inch boring mills	4
Double rod boring machine	1
Cylinder borer	1
3 spindle cylinder borer	1
60-inch horizontal boring mills	2
36-inch boring mills, turret	2
	21

PLANERS.

72-inch by 84-inch by 12-foot cylinder planer	1
72-inch by 72-inch by 36-foot frame planer	1
60-inch by 60-inch by 18-foot planers	2
48-inch by 48-inch by 10-foot planers	6
36-inch by 36-inch by 10-foot planers	10
30-inch by 30-inch by 8-foot planer	4
	24

SHAPERS.

18-inch double head shapers	4
16-inch stroke shapers	6
14-inch stroke shapers	2
	12

SLOTTERS.

Double head frame slotter	1
18-inch slotters	2
16-inch slotters	2
14-inch slotters	4
12-inch slotters	2
	11

MILLERS.

Vertical millers	2
Universal millers	2
Universal milling machine, tool room	1
Horizontal millers	2
Heavy horizontal and vertical	2
	9

72-inch Universal radial drills	2
72-inch radial drill	1
3 spindle frame drill	1
60-inch radial drill presses	8
36-inch vertical drills	6
24-inch vertical drills	3
High speed drills	3
Drill centering machines	2
	26

GRINDERS.

Universal grinders	2
72-inch guide bar grinders	2
Universal tool grinders	2
Drill grinders	2
Piston rod grinders	2
Horizontal grinders	6
	16

MISCELLANEOUS.

400-ton wheel press	1
Pipe cutters	3
2½-inch double head bolt cutters	2
2-inch bolt cutters	2
1½-inch bolt cutters	2
Tool dresser furnace	1
Tool dresser trip hammer	1
Presses for driving boxes and rod bearings	2
Universal cold saw	1
Grind stones	2
	17

Classified List of Machine Tools for 1, 12, 15, 24 and 48 Erecting Shop Pit

LATHES.

	100 in.	90 in.	42 in.	36 in.	30 in.	24 in.	20 in.	18 in.	16 in.	2x24 in.
Per Pit	1/24	1/24	1/12	1/4	1/3	5/12	1/2	5/6	5/6	1/12
Per 12 Pits	1/2	1/2	1	3	4	5	6	10	10	1
Per 15 Pits	5/8	5/8	1 1/4	4	5	6 1/4	7 1/2	12 1/2	12 1/2	1 1/4
Per 24 Pits	1	1	2	6	8	10	12	20	20	2
Per 48 Pits	2	2	4	12	16	20	24	40	40	4

LATHES—Continued.

	2½x24 in.	4¾x24 in.	6 in.	Special Bolt	Cyl.	Axle	Wheel Quartering	Total
Per Pit	1/12	1/8	1/24	1/24	1/24	1/12	1/24	3 11/12
Per 1 Pit	1	1 1/2	1/2	1/2	1/2	1	1/2	47
Per 12 Pits	1 1/4	1 7/8	5/8	5/8	5/8	1 1/4	5/8	53
Per 24 Pits	2	3	1	1	2	2	1	94
Per 48 Pits	4	6	2	2	4	4	2	188

BORING MILLS.

	96 in.	84 in.	72 in.	51 in.	42 in.	36 in.	D Rod Borer	Cyl. Borer	Spindle Cyl.	60 in. Hori.	Total
Per Pit	1/24	1/24	1/12	1/4	1/6	1/12	1/24	1/24	1/24	1/12	7/8
Per 12 Pits	1/2	1/2	1	3	2	1	1/2	1/2	1/2	1	10 1/2
Per 15 Pits	5/8	5/8	1 1/4	4	2 1/2	1 1/4	5/8	5/8	5/8	1 1/4	12
Per 24 Pits	1	1	2	6	4	2	1	1	1	2	21
Per 48 Pits	2	2	4	12	8	4	2	2	2	4	42

PLANERS.

	72 in.	60 in.	48 in.	36 in.	30 in.	72 in.	Total
Per Pit	1/24	1/12	1/4	5/12	1/6	1/24	1
Per 12 Pits	1/2	1	3	5	2	1/2	12
Per 15 Pits	5/8	1 1/4	3 3/4	6 1/4	2 1/2	5/8	15
Per 24 Pits	1	2	6	10	4	1	24
Per 48 Pits	2	4	12	20	8	2	48

SHAPERS.

	18 in.	16 in.	14 in.	Total
Per Pit	1/6	1/4	1/12	1/2
Per 12 Pits	2	3	1	6
Per 15 Pits	2 1/2	3 3/4	1 1/4	7 1/2
Per 24 Pits	4	6	2	12
Per 48 Pits	8	12	4	24

SLOTTERS.

	18 in.	16 in.	14 in.	12 in.	Double head frame	Total
Per Pit	1/12	1/12	1/6	1/12	1/48	21/48
Per 12 Pits	1	1	2	1	1/4	5 1/4
Per 15 Pits	1 1/4	1 1/4	2 1/2	1 1/4	15/48	6 27/48
Per 24 Pits	2	2	4	2	1/2	11
Per 48 Pits	4	4	8	4	1	21

MILLERS.

	Univ.	Vert.	Hori.	Tool room	Heavy Hori.	Total
Per Pit	1/12	1/12	1/12	1/24	1/12	3/8
Per 12 Pits	1	1	1	1/2	1	4 1/2
Per 15 Pits	1 1/4	1 1/4	1 1/4	5/8	1 1/4	5 5/8
Per 24 Pits	2	2	2	1	2	9
Per 48 Pits	4	4	4	2	4	18

GRINDERS.

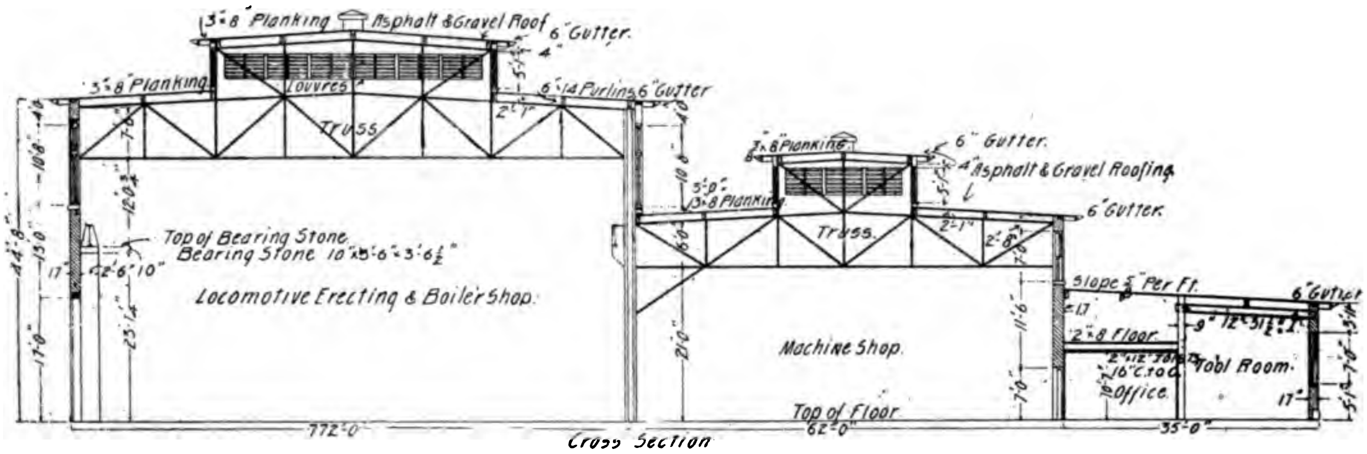
	72 in. Guide	Drill	Piston rod	Horizontal	Universal	Universal Tool	Total
Per Pit	1/12	1/12	1/12	1/4	1/12	1/12	2/3
Per 12 Pits	1	1	1	3	1	1	8
Per 15 Pits	1 1/4	1 1/4	1 1/4	3 3/4	1 1/4	1 1/4	10
Per 24 Pits	2	2	2	6	2	2	16
Per 48 Pits	4	4	4	12	4	4	32

DRILLS.

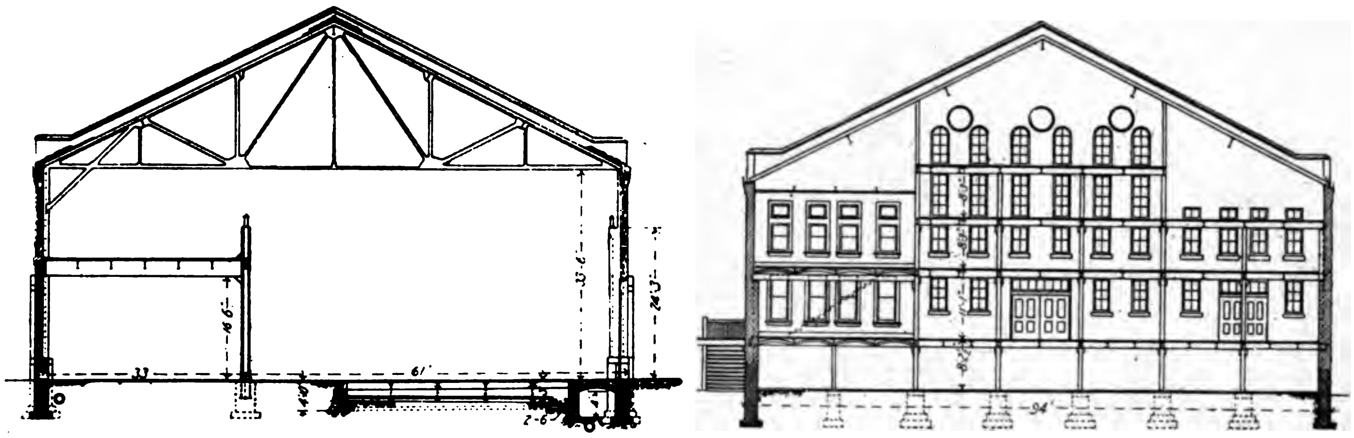
	72 in.	60 in.	36 in.	24 in.	High speed	Centering	3 spindle frame	Total
Per Pit	1/8	1/3	1/4	1/8	1/8	1/12	1/24	1/2
Per 12 Pits	1 1/2	4	3	1 1/2	1 1/2	1	1/2	1/2
Per 15 Pits	1 7/8	5	3 3/4	1 7/8	1 7/8	1 1/4	5/8	16 1/4
Per 24 Pits	3	8	6	3	3	2	1	26
Per 48 Pits	6	16	12	6	6	4	2	52

MISCELLANEOUS.

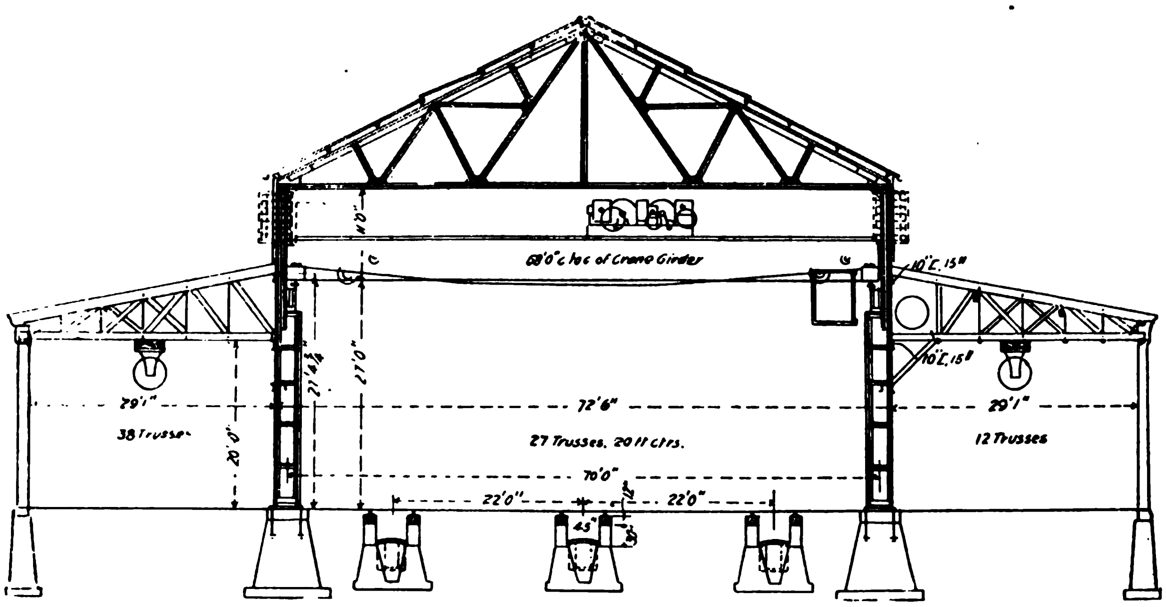
	Wheel Press	Pipe Cutter	Bolt Cutter	Tool Furnace	Trip Hammer	Press	Cold Saw	Grind Stone	Total
Per Pit	1/24	1/8	1/4	1/24	1/24	1/24	1/24	1/12	2/3
Per 12 Pits	1/2	1 1/2	3	1/2	1/2	1/2	1/2	1	8
Per 15 Pits	5/8	1 7/8	3 3/4	5/8	5/8	5/8	5/8	1 1/4	10
Per 24 Pits	1	3	6	1	1	2	1	2	17
Per 48 Pits	2	6	12	2	2	4	2	4	34



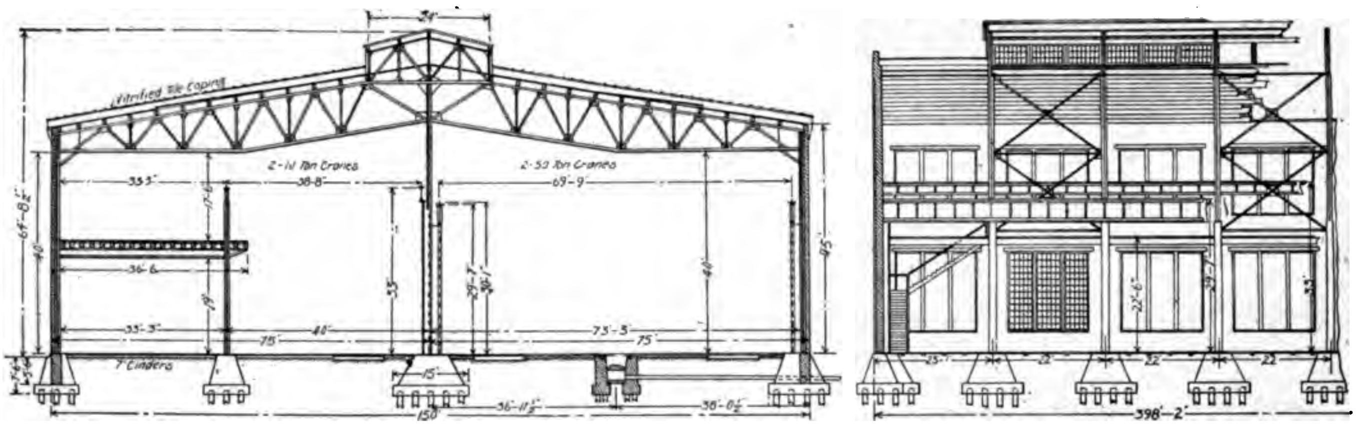
CROSS SECTION OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.—ERECTING FLOOR AND BOILER DEPARTMENT IN MAIN BUILDING. MACHINE DEPARTMENT IN SIDE BAY. TRANSVERSE ERECTING PITS.



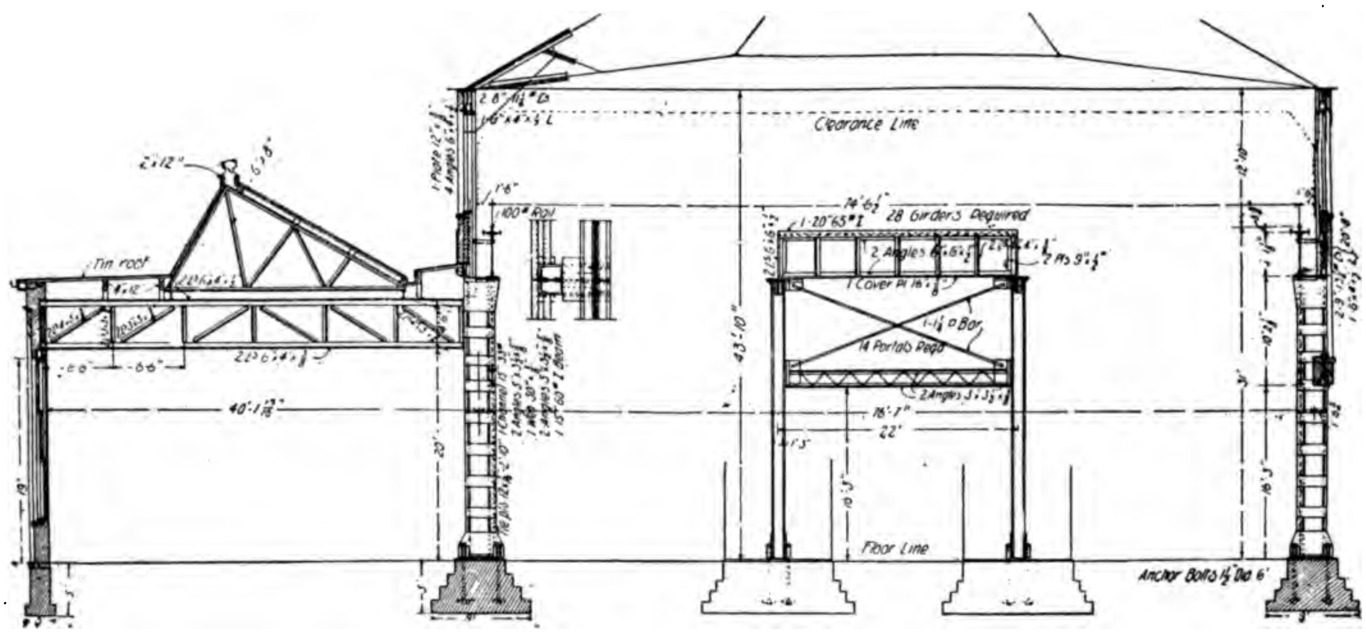
CROSS SECTION AND END ELEVATION OF LOCOMOTIVE SHOP AT OELWEIN, IA., C. G. W. RY.—ROOF TRUSS SPANS ENTIRE WIDTH OF SHOP. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. TRANSVERSE ERECTING PITS.



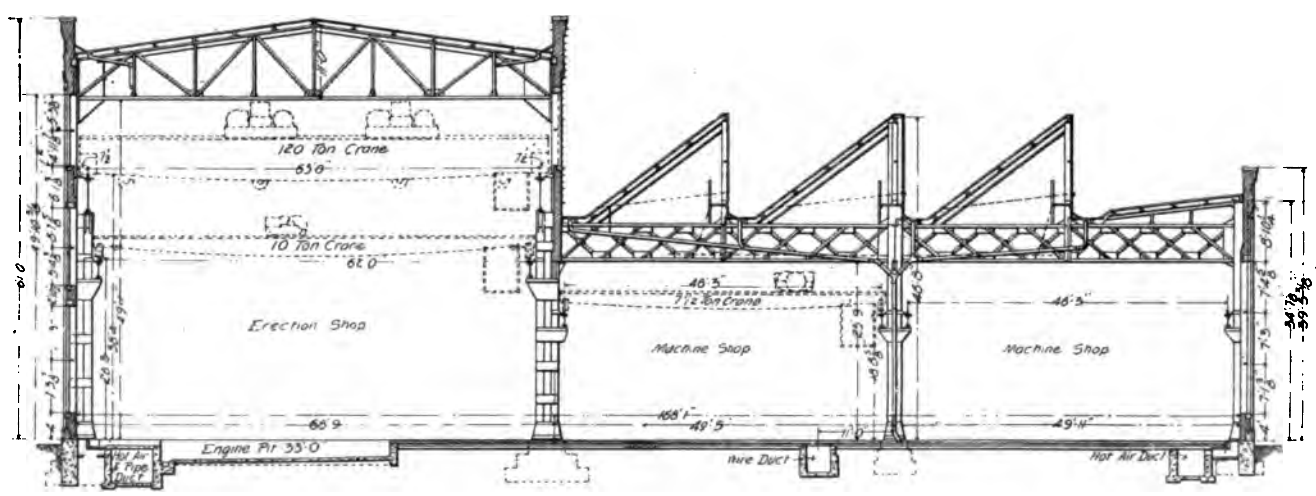
CROSS SECTION OF LOCOMOTIVE SHOP AT DU BOIS, PA., B. R. & P. RY.—ERECTING FLOOR IN CENTRAL BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON OPPOSITE SIDES OF ERECTING BAY. LONGITUDINAL ERECTING PITS. BOILER SHOP IN ISOLATED BUILDING.



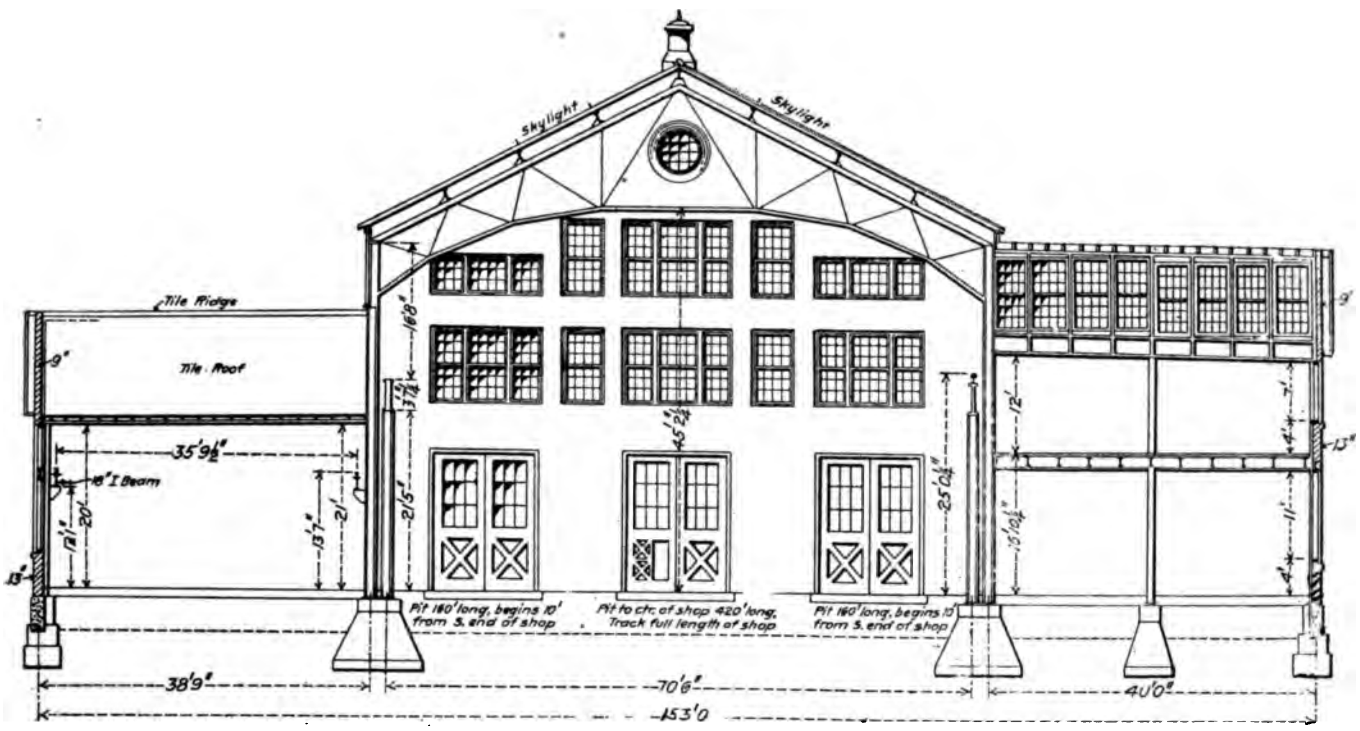
CROSS SECTION AND PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT OMAHA, NEBR., U. P. R. R.—ERECTING FLOOR AND MACHINE TOOL DEPARTMENT IN PARALLEL BAYS OF SAME WIDTH. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. LONGITUDINAL ERECTING PITS.



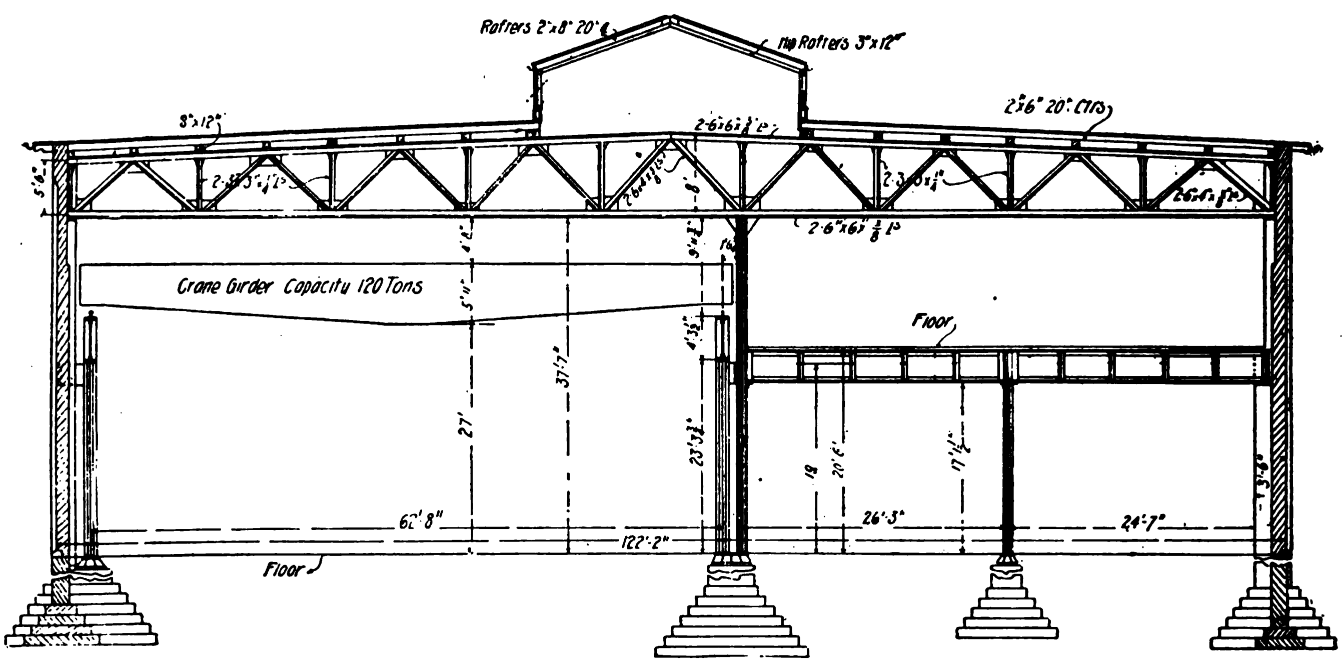
CROSS SECTION OF LOCOMOTIVE SHOP AT DANVILLE, ILL., C. & E. I. R. R.—ERECTING FLOOR IN MAIN BAY, WITH MACHINE TOOL EQUIPMENT IN SIDE BAY. HEAVY MACHINES IN MAIN BAY UNDER ERECTING FLOOR CRANE. TRANSVERSE ERECTING PITS.



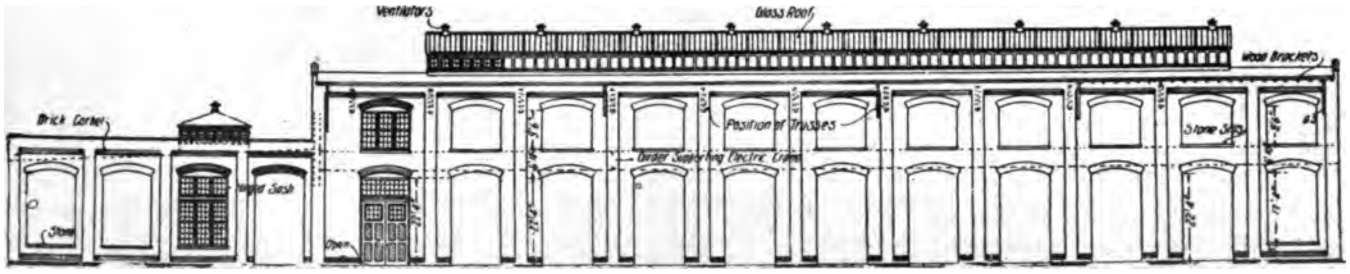
CROSS SECTION OF LOCOMOTIVE SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.—ERECTING FLOOR IN MAIN BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON SAME SIDE OF ERECTING BAY—TRANSVERSE ERECTING PITS.



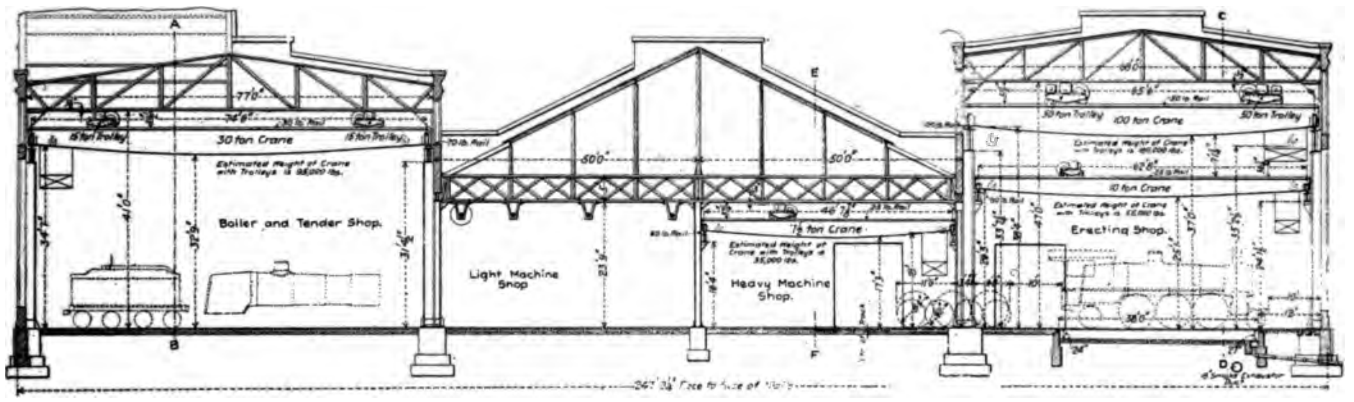
CROSS SECTION OF LOCOMOTIVE SHOP AT TOPEKA, KAN., A. T. & S. F. RY.—ERECTING FLOOR IN CENTRAL BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON OPPOSITE SIDES OF ERECTING BAY. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. LONGITUDINAL ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



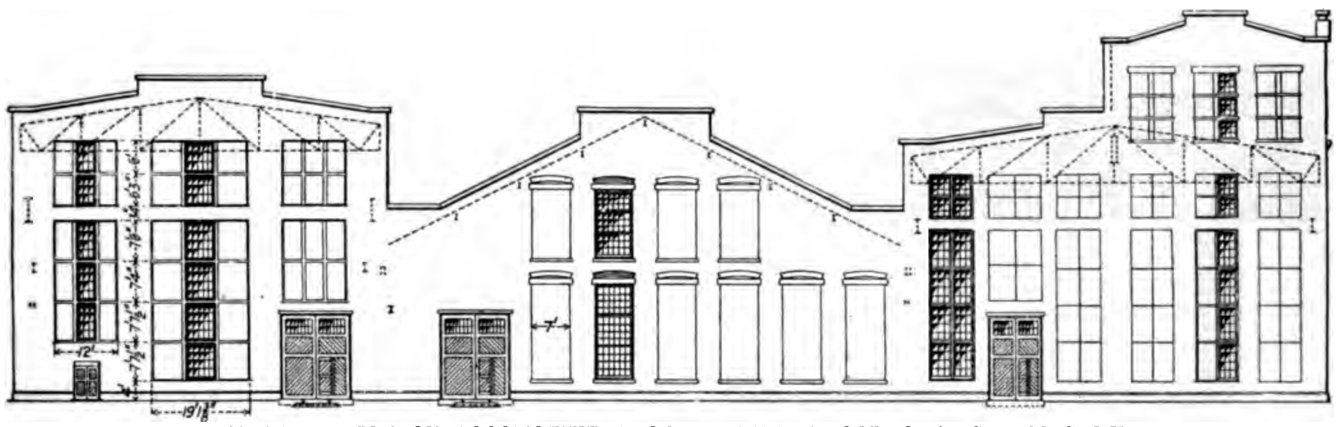
CROSS SECTION OF LOCOMOTIVE SHOP AT EAST ST. LOUIS, ILL., T. R. R. OF ST. L.—ERECTING FLOOR IN MAIN BAY WITH MACHINE TOOL EQUIPMENT IN SIDE BAY AND HEAVY MACHINES IN ONE END OF ERECTING BAY SERVED BY CRANE. TRANSVERSE ERECTING PITS.



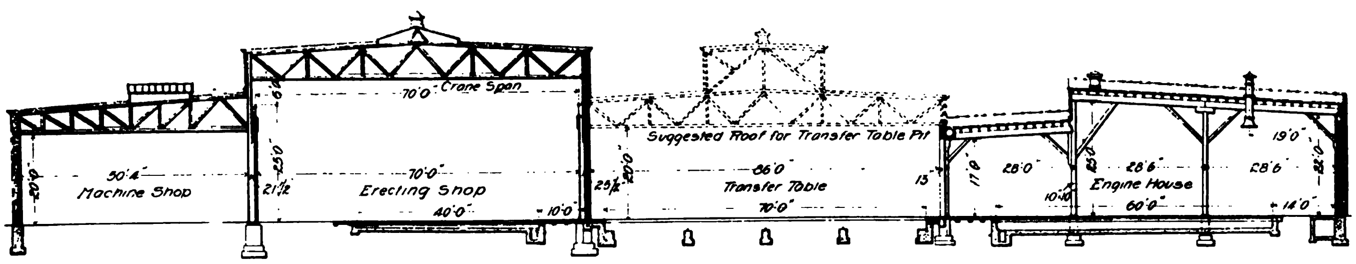
SIDE ELEVATION OF LOCOMOTIVE SHOP, WITH BLACKSMITH SHOP AT END, EAST ST. LOUIS, ILL., T. R. R. OF ST. L.



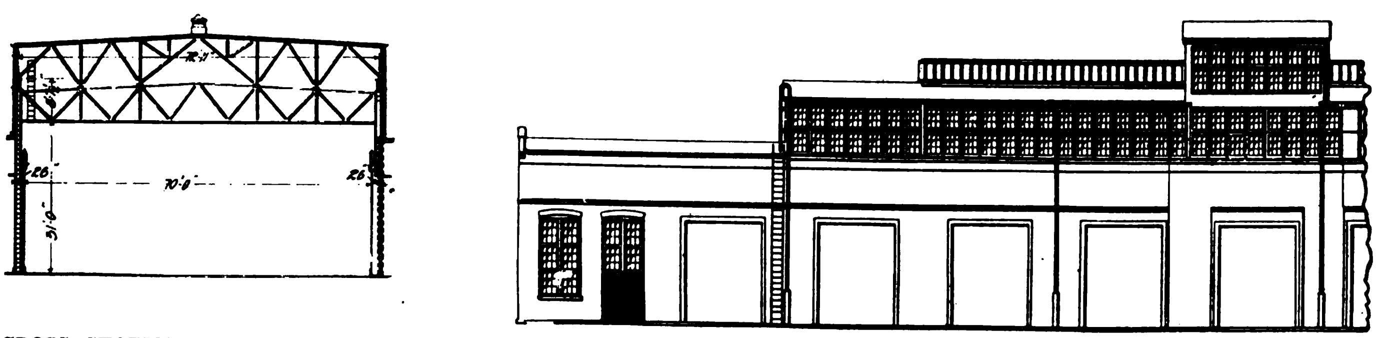
CROSS SECTION OF LOCOMOTIVE SHOP AT COLLINWOOD, O., L. S. & M. S. RY.—ERECTING AND BOILER SHOP IN OUTSIDE BAYS WITH MACHINE TOOL EQUIPMENT IN TWO INTERMEDIATE BAYS. TRANSVERSE ERECTING PITS.



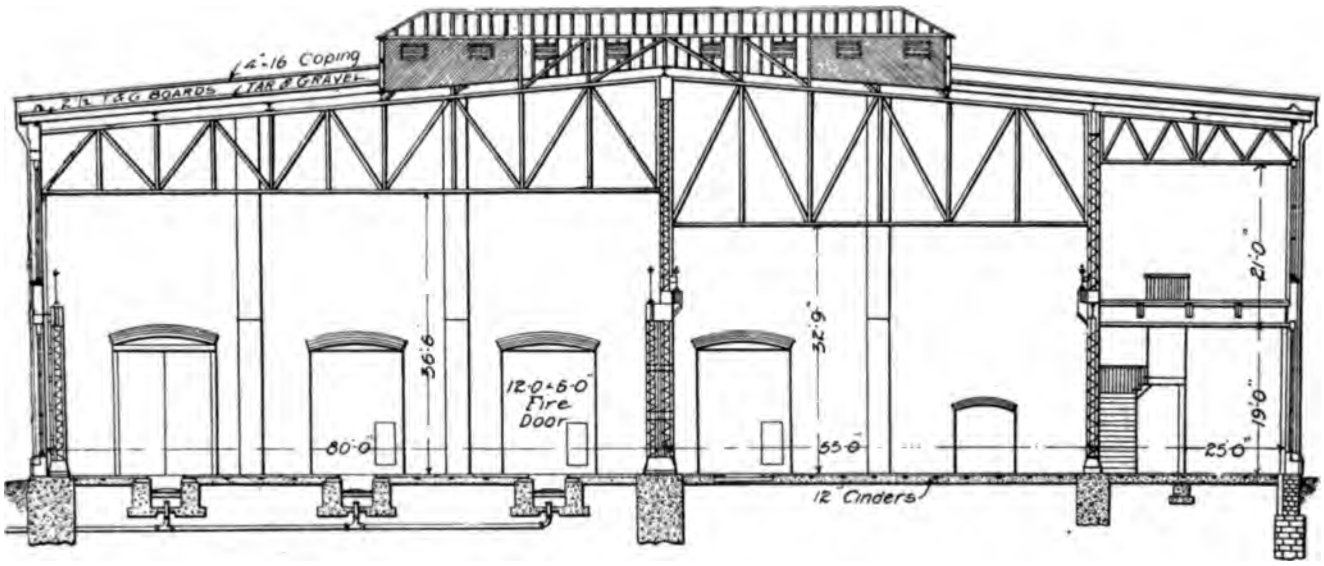
END ELEVATION OF LOCOMOTIVE SHOP AT COLLINWOOD, O., L. S. & M. S. RY.



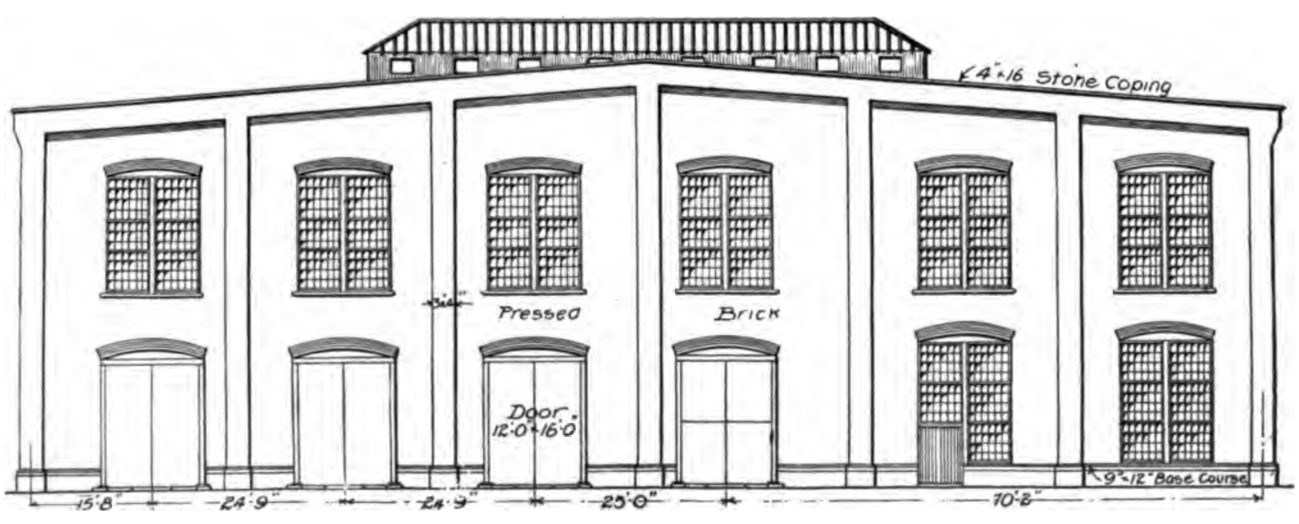
CROSS SECTION OF LOCOMOTIVE SHOP AND ENGINE HOUSE AT GRAND RAPIDS, MICH., P. M. R. R.—ERECTING SHOP AND SQUARE ENGINE HOUSE SERVED BY COMMON TRANSFER TABLE.



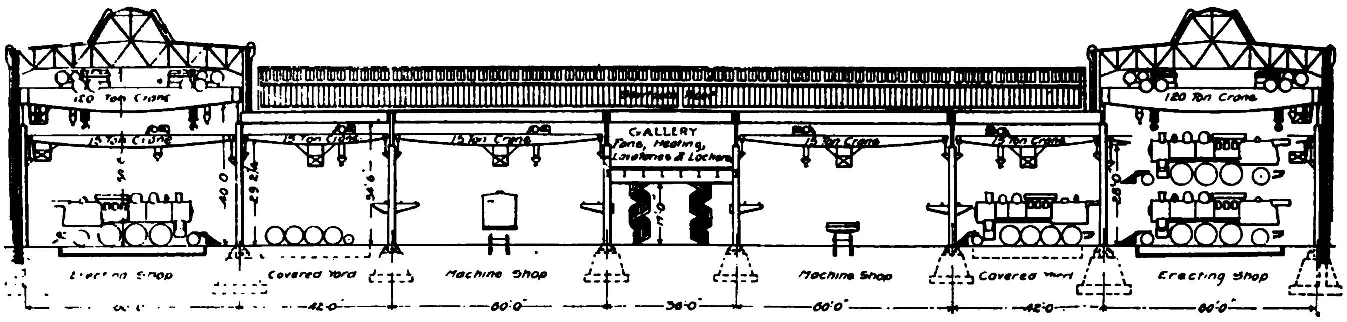
CROSS SECTION OF ERECTING BAY THROUGH PIT SERVED BY STATIONARY ELECTRIC HOIST, AND SIDE ELEVATION OF ERECTING SHOP AT GRAND RAPIDS, MICH., P. M. R. R.



CROSS SECTION OF LOCOMOTIVE SHOP AT ANGUS (MONTREAL), C P. RY.—ERECTING FLOOR AND MACHINE TOOL DEPARTMENT IN PARALLEL BAYS OF SAME WIDTH. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. LONGITUDINAL ERECTING BAYS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.

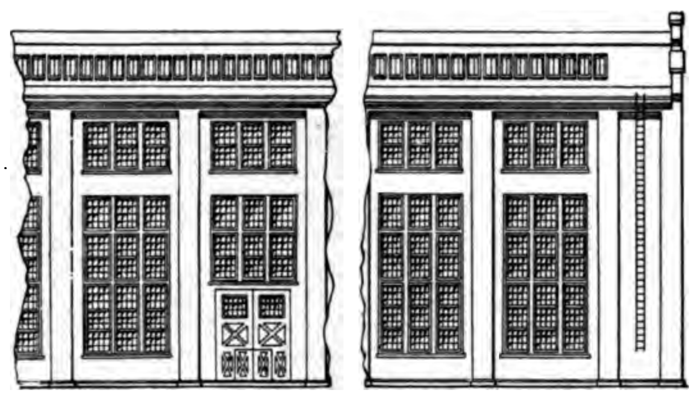


END ELEVATION OF LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

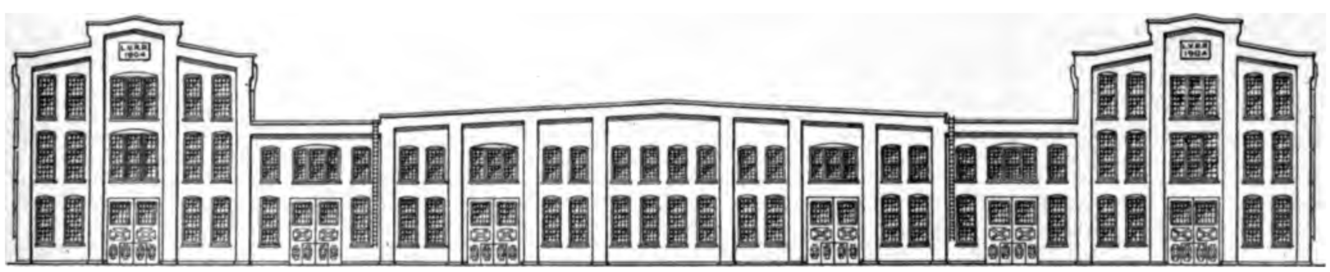


SAYRE SHOPS, LEHIGH VALLEY—CROSS SECTION SHOWING ERECTING SHOPS, MACHINE SHOPS, AND COVERED YARDS.

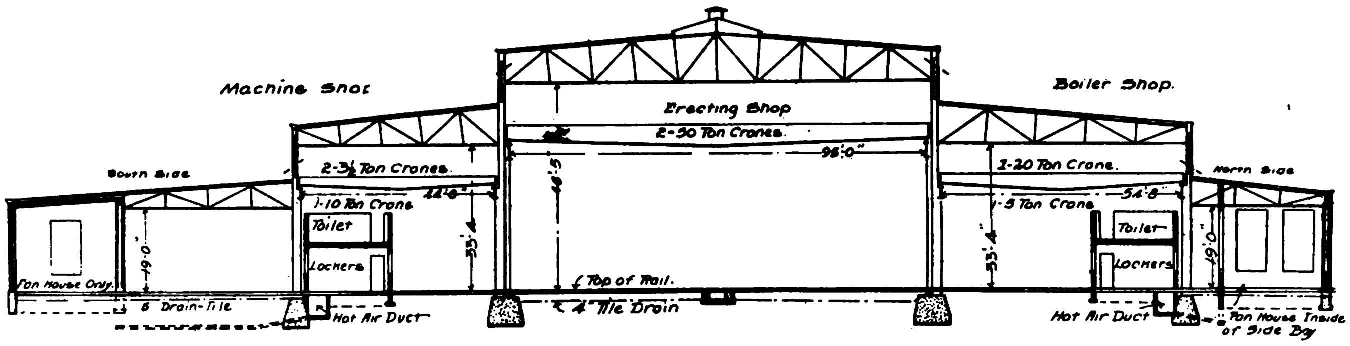
CROSS SECTION OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.—ERECTING FLOORS IN TWO OUTSIDE BAYS. TWO COVERED YARDS ADJACENT TO ERECTING FLOORS. MACHINE TOOL EQUIPMENT IN TWO INTERMEDIATE BAYS AND AUXILIARY DEPARTMENTS IN CENTRAL BAY. TRANSVERSE ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



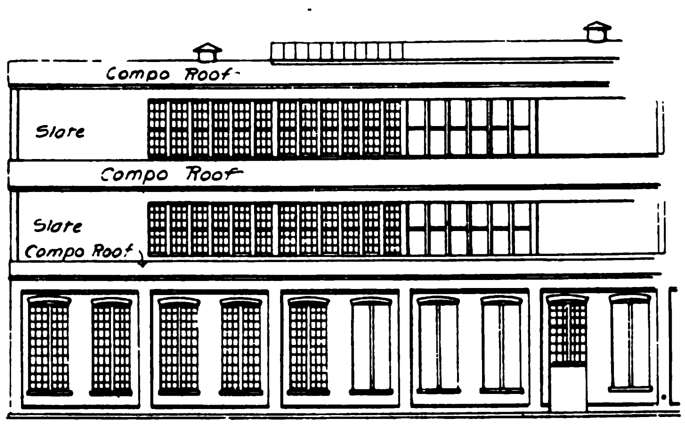
PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.



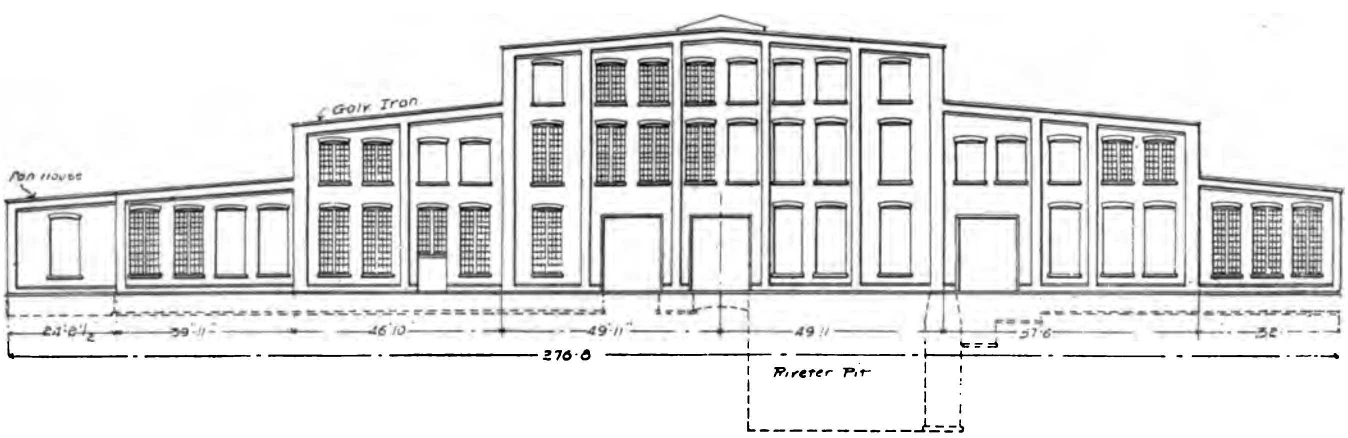
END ELEVATION OF LOCOMOTIVE SHOP AT SAYRE, PA., L.V. R. R.



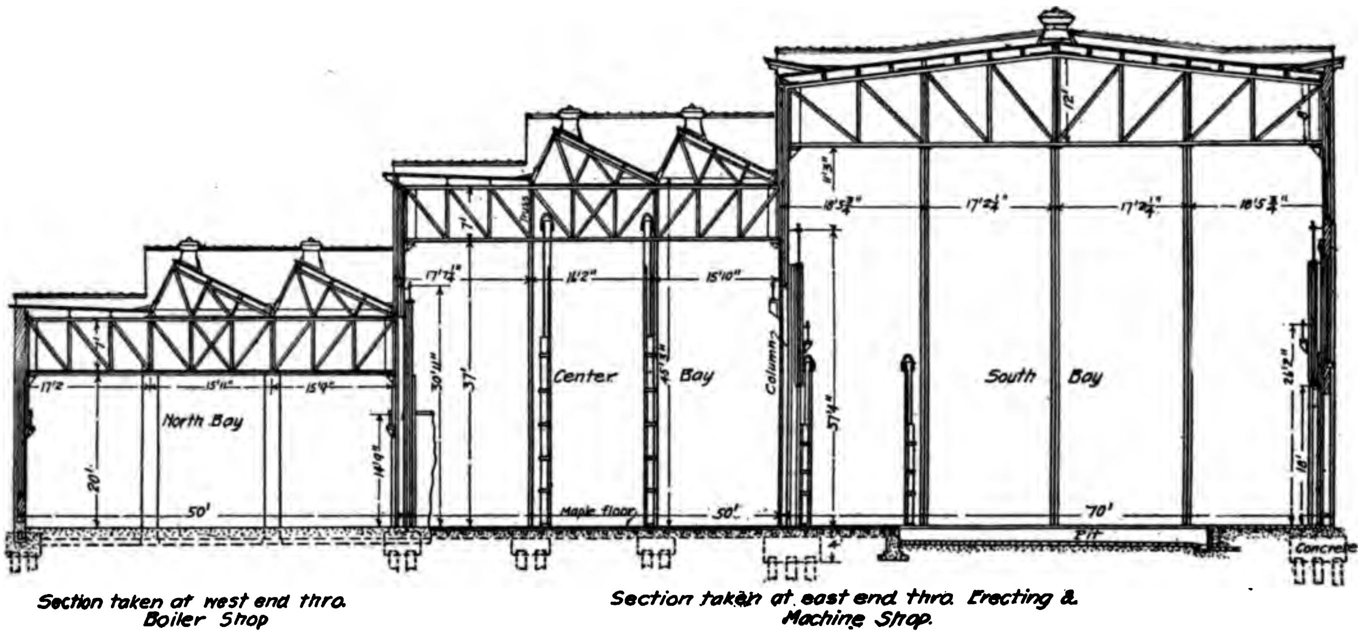
CROSS SECTION OF LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.—ERECTING FLOOR IN CENTRAL BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON OPPOSITE SIDES OF ERECTING BAY. DIAGONAL ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



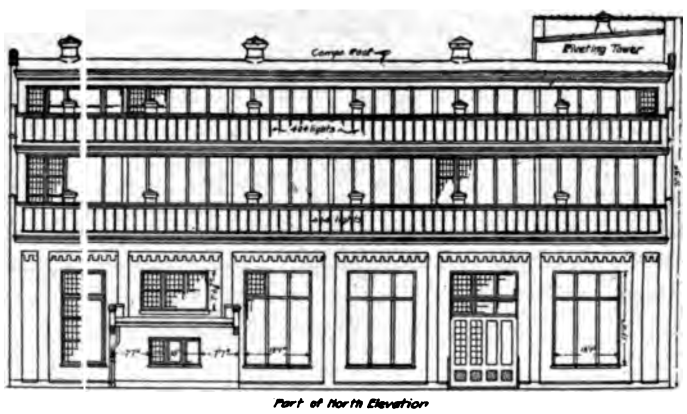
PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.



END ELEVATION OF LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.

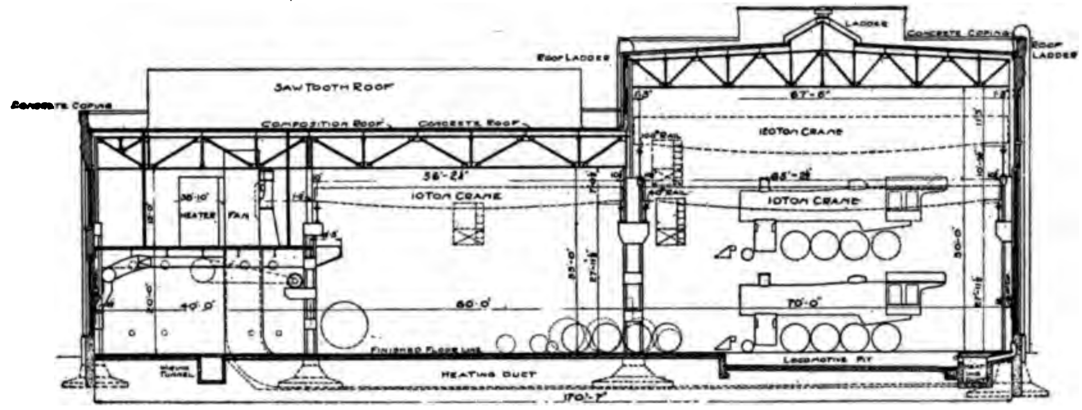


CROSS SECTION OF LOCOMOTIVE SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.—ERECTING FLOOR IN MAIN BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON SAME SIDE OF ERECTING BAY. TRANSVERSE ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.

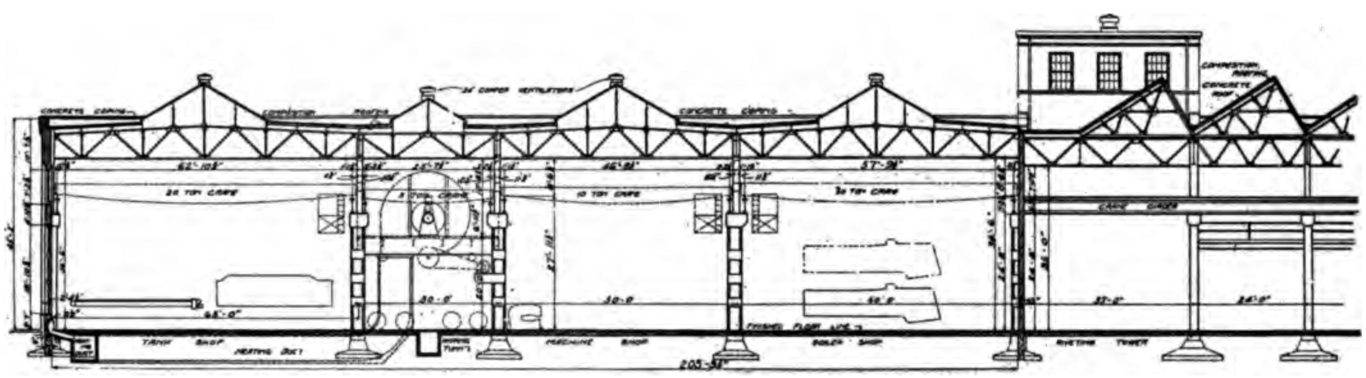


PARTIAL SIDE ELEVATION OF ERECTING SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.

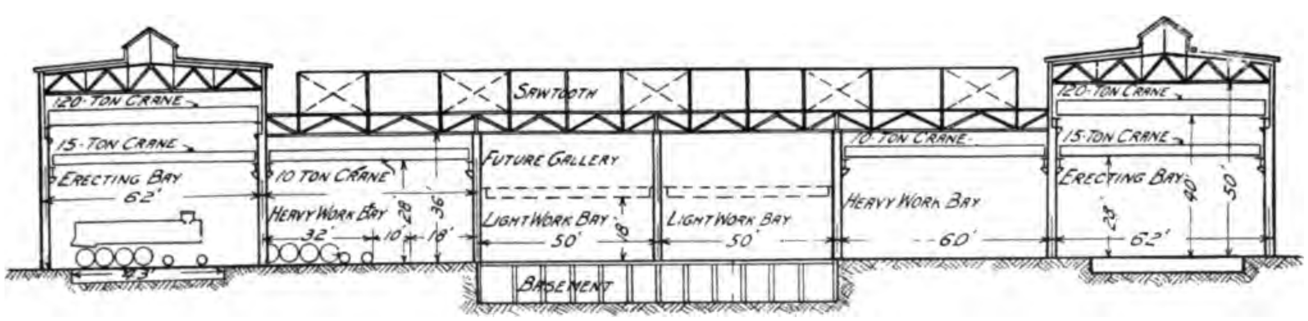
END AND PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOPAT SOUTH LOUISVILLE, KY., L. & N. R. R.



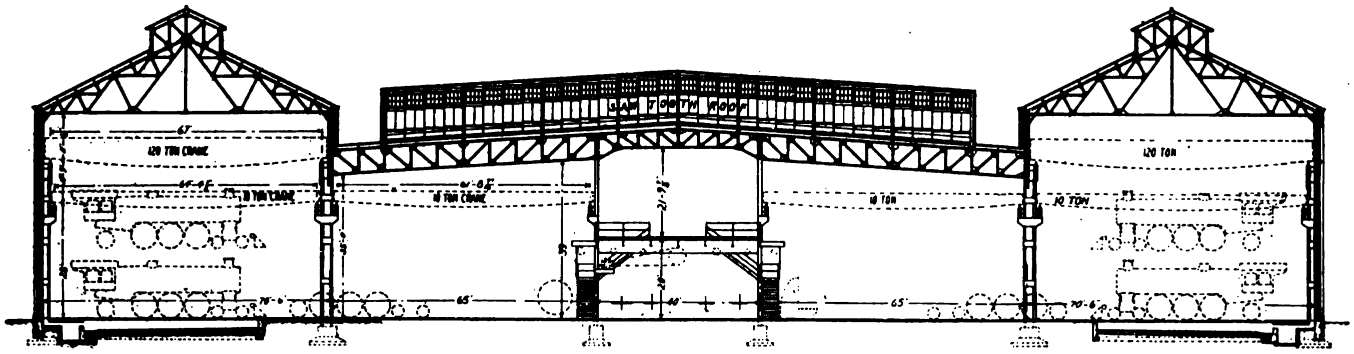
CROSS SECTION OF MACHINE AND ERECTING SHOP AT BATTLE CREEK, MICH., GRAND TRUNK RAILWAY.



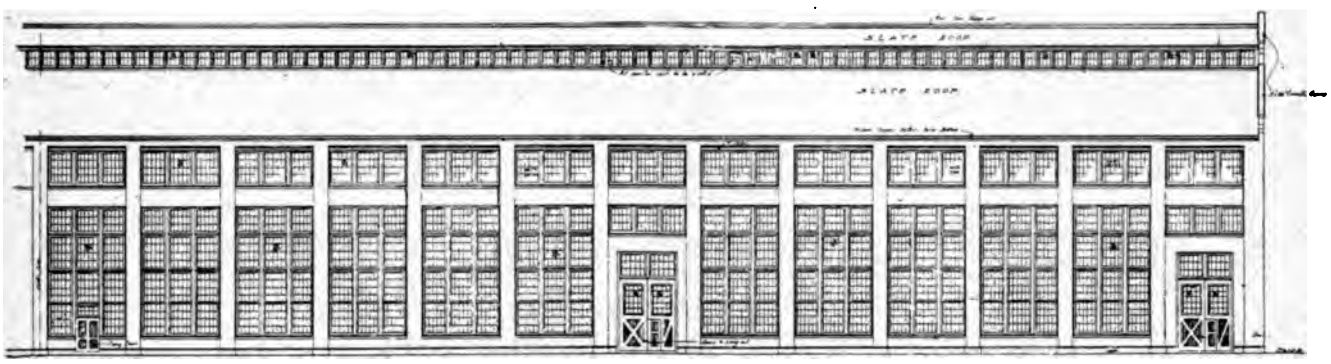
CROSS SECTION OF BOILER AND TANK SHOP AT BATTLE CREEK, MICH., GRAND TRUNK RAILWAY.



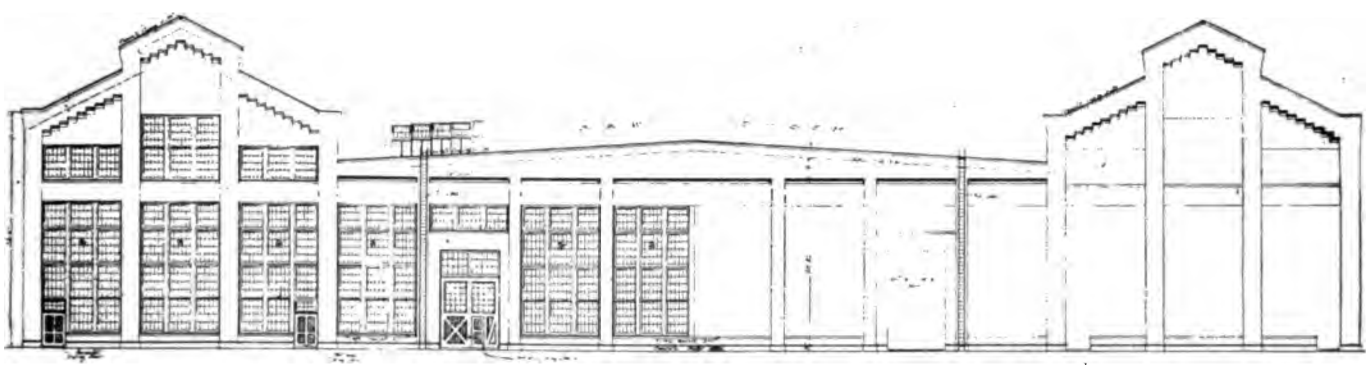
CROSS SECTION OF LOCOMOTIVE SHOP AT SCRANTON, PA., DELAWARE, LACKAWANNA & WESTERN RAILROAD.



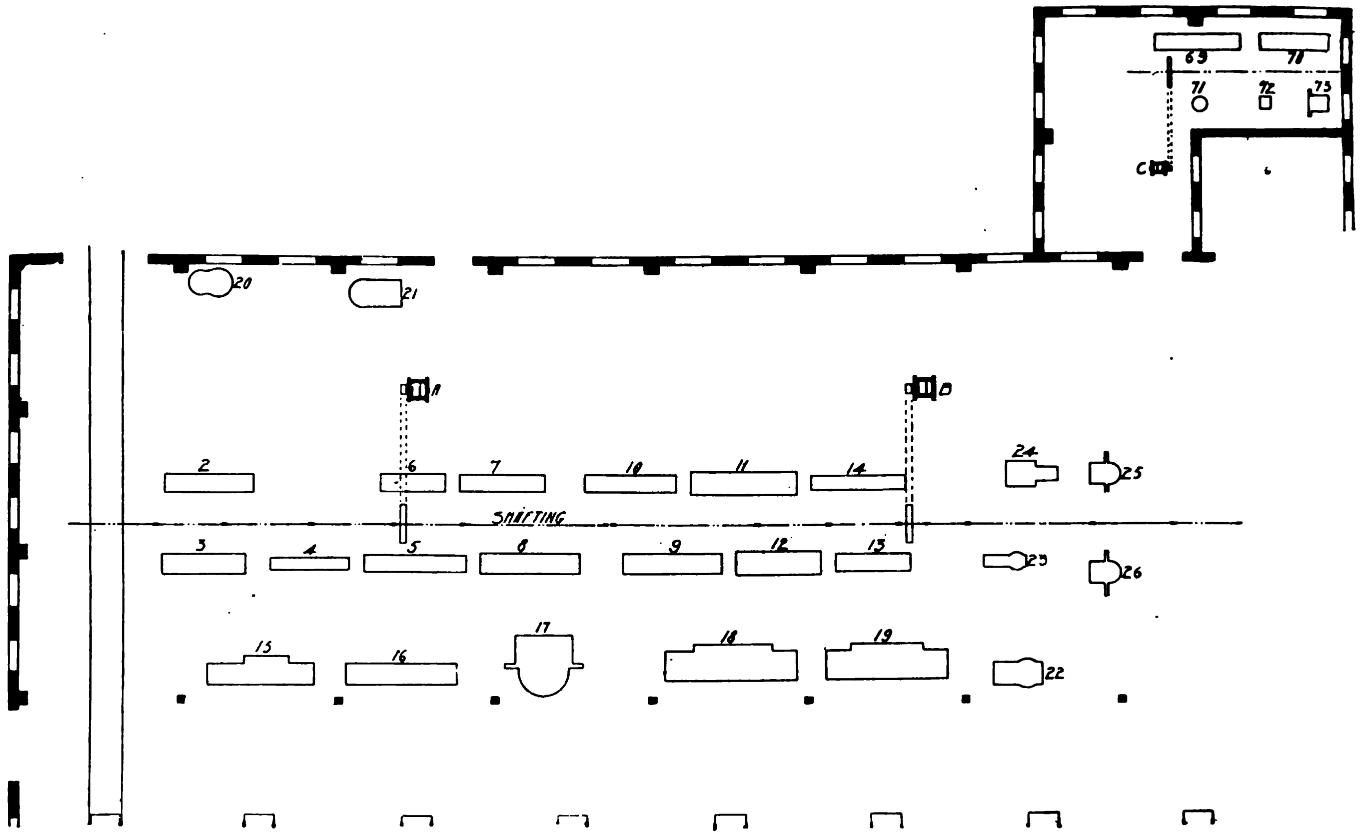
CROSS SECTION OF LOCOMOTIVE SHOP AT BEECH GROVE (INDIANAPOLIS), IND., C. C. C. & ST. L. RY.—MODIFICATION OF LEHIGH VALLEY RY. LOCOMOTIVE SHOP AT SAYRE, PA.



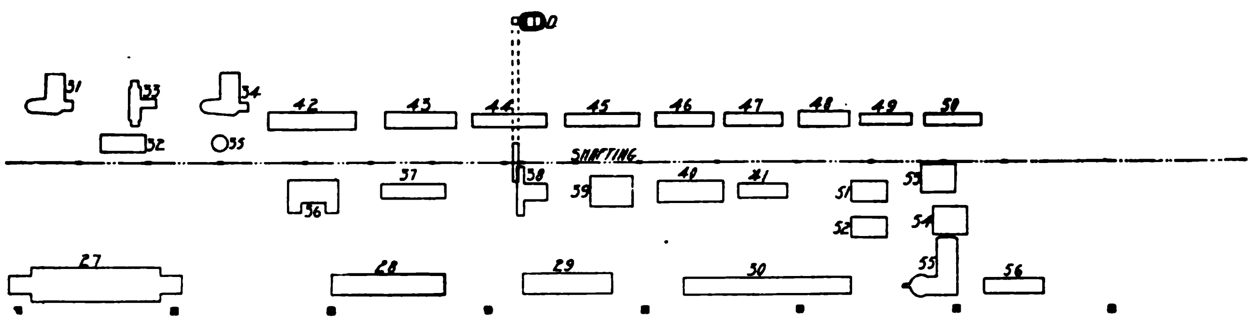
PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT BEECHGROVE, C. C. C. & ST. L. RY.



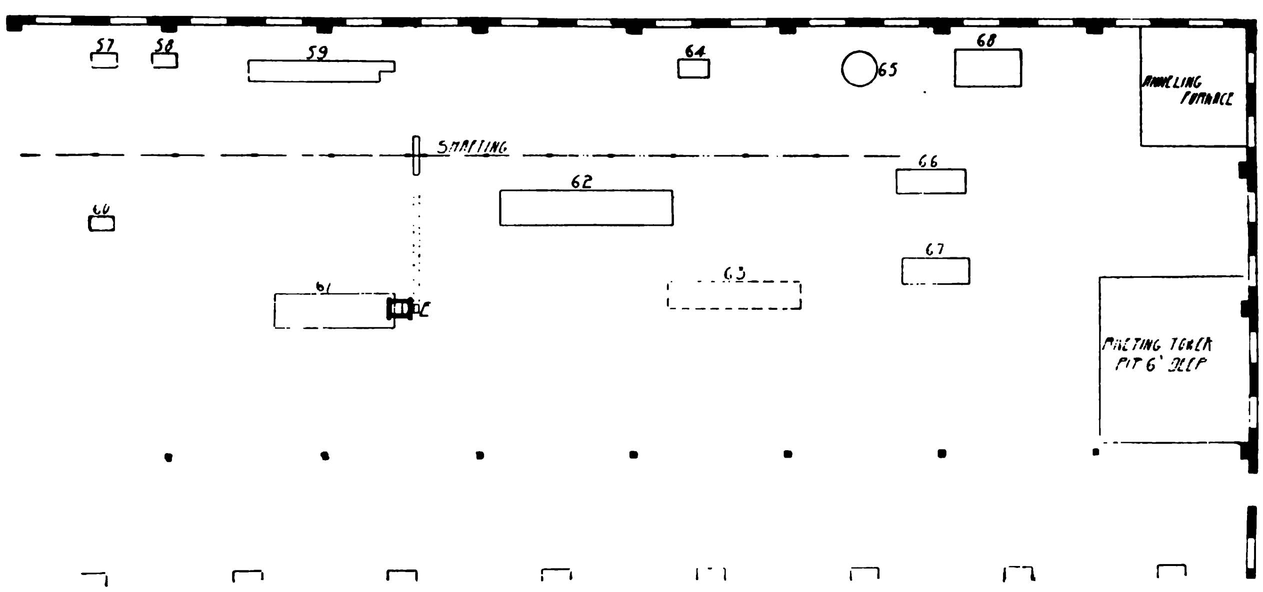
END ELEVATION OF LOCOMOTIVE SHOP AT BEECH GROVE, C. C. C. & ST. L. RY.



MACHINE TOOL LAYOUT IN EAST END OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



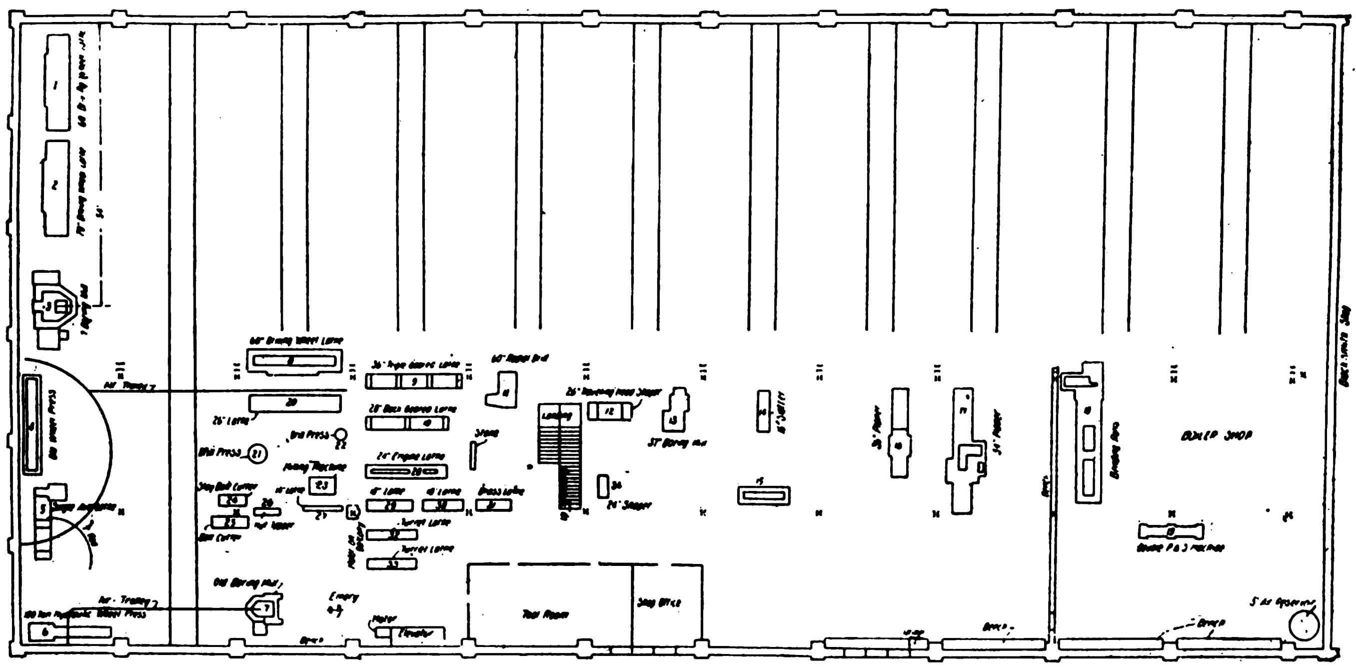
MACHINE TOOL LAYOUT IN CENTRAL BAY OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



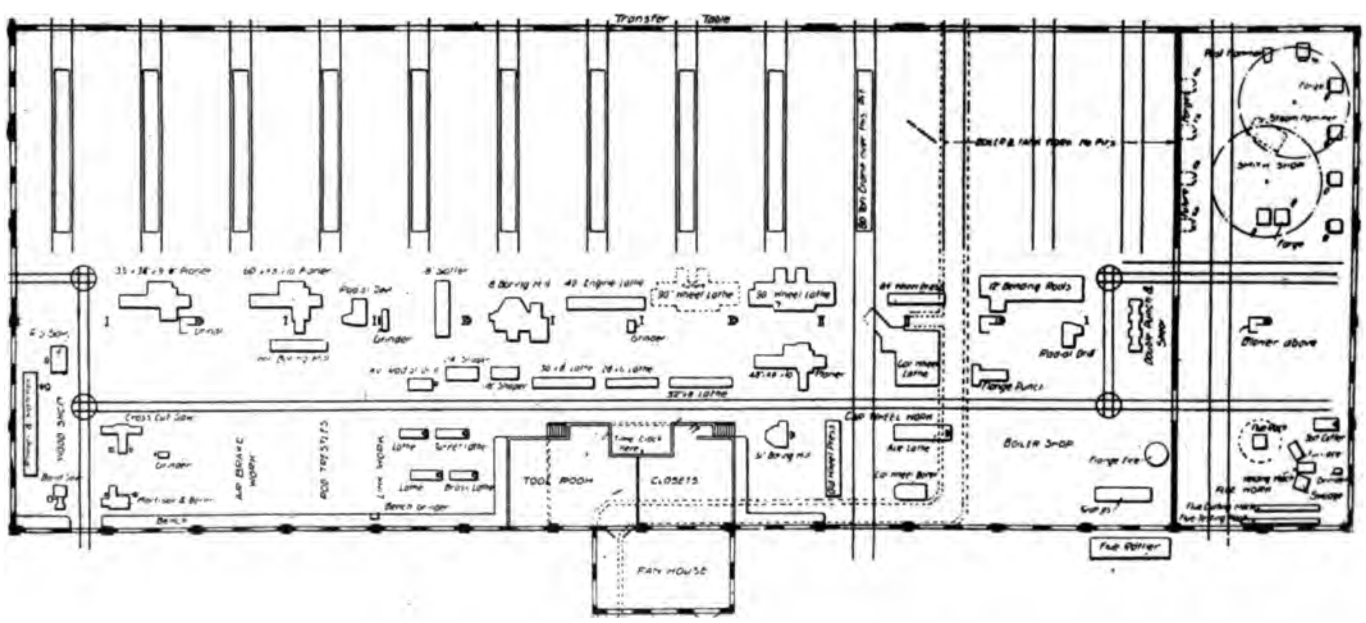
MACHINE TOOL LAYOUT IN BOILER DEPARTMENT, WEST END OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.

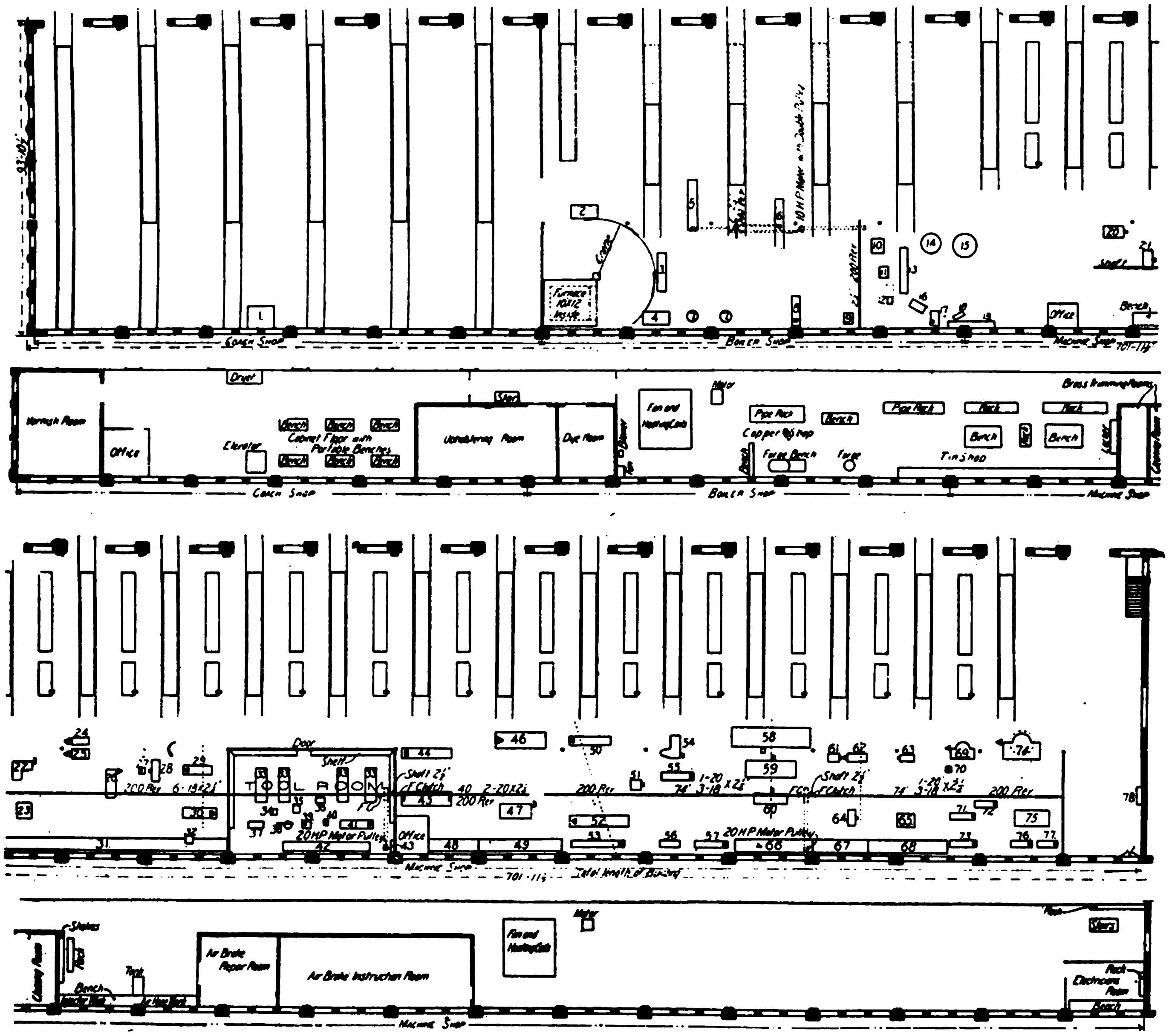
No.	Description.
1	Wheel press (old).
2	Lathe, double end axle (new).
3	Lathe, axle (old).
4	Lathe, axle (old).
5	Lathe, axle (new).
6	Lathe, 20-in. (old).
7	Lathe, 32-in. (new).
8	Lathe, 30-in. (new).
9	Lathe, 30-in. new).
10	Lathe, 36-in. (new).
11	Lathe, 38-in. (old).
12	Lathe, 32-in. (old).
13	Lathe, 28-in. (old).
14	Lathe (old).
15	Lathe, car wheel, 28-in.(new).
16	Driving wheel press (old).
17	Boring mill, 7-ft.
18	Driving wheel lathe (old).
19	Driving wheel lathe (old).
20	Wheel borer (old).
21	Wheel borer (new).
22	Slotter (old).
23	Slotter, 14-in. (new).
24	Horizontal boring mill. (old).
25	Boring mill, 37-in. (new).
26	Boring mill, 37-in. (new).
27	Planer, 4-head (old).
28	Planer, 38x38-in. (new).
29	Planer, 32x32-in. (old).
30	Planer, frog (old).
31	Radial drill, 60-in., rotating arm (new).
32	Drill press (old).
33	Surface grinder, 24-in. (new).
34	Radial drill, 60-in. (new).
35	Drill press, 32-in. (new).
36	Shaper, 18-in. (new).
37	Planer, 26x26-in. (old).
38	Milling machine (new).
39	Milling machine (old).
40	Lathe, cabinet (new).
41	Lathe, turret (new).
42	Lathe, 25-in. (old).
43	Lathe, 20-in. (old).
44	Lathe, 16-in. (new).
45	Lathe, 16-in. (new).
46	Lathe, 18-in. (old).
47	Lathe, turret (new).
48	Lathe, turret (old).
49	Lathe, Fox (old).
50	Lathe, 16-in. (old).
51	Nut tapper (new).
52	Nut tapper (old).
53	Bolt cutter (old).
54	Bolt cutter (old).
55	Radial drill (old).
56	Arch bar drill (new).
57	Drill press (old).
58	Drill press (old).
59	Plate planer.
60	Plate shears.
61	Punch and shears (old).
62	Rolls (old).
63	Flue rattler, under floor (old).
64	Flue welder.
65	Small fire.
66	Flange clamp.
67	Face plate.
68	Flange fire.
69	Lathe, 14-in. (new).
70	Lathe, 14-in. (new).
71	Drill, 32-in. (new).
72	Tool grinder (new).
73	Milling machine (new).
A	Motor, 20-h. p.
B	Motor, 20-h. p.
C	Motor, $3\frac{1}{2}$-h. p.
D	Motor, 30-h. p.
E	Motor, 30-h. p.



FLOOR PLAN OF LOCOMOTIVE SHOP AT EAST ST. LOUIS, ILL., T. R. R. OF ST. L.—SHOWING LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS.



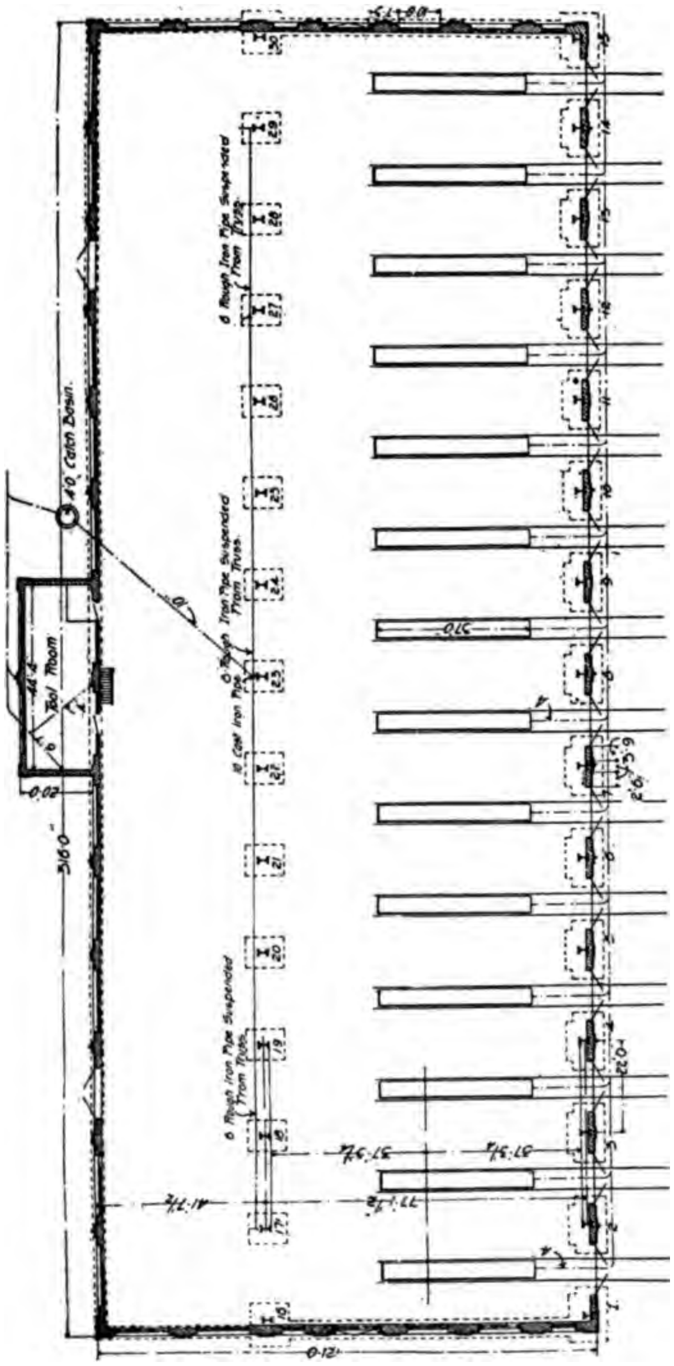
FLOOR PLAN OF LOCOMOTIVE SHOP AT GRAND RAPIDS, MICH., P. M. R. R.—SHOWING LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS.



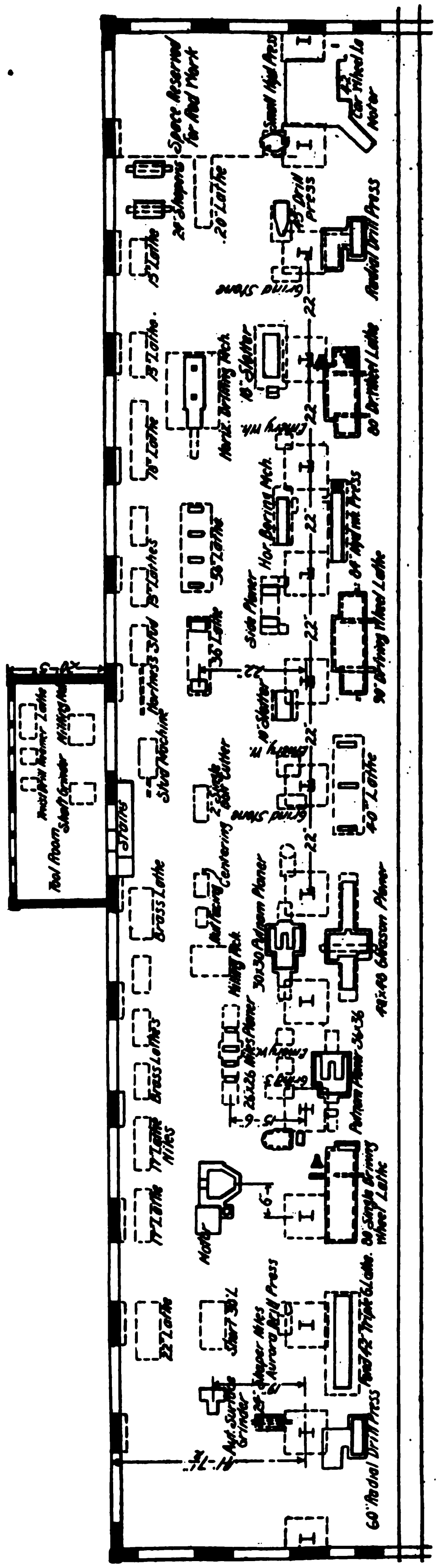
FLOOR PLAN OF LOCOMOTIVE AND CAR SHOP AT OELWEIN, IA., C. G. W. RY.—SHOWING LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS, AND LOCATION OF AUXILIARY DEPARTMENTS ON BALCONY —THE LOWER ILLUSTRATION SHOULD BE READ AS A CONTINUATION OF THE UPPER.

LIST OF MACHINE TOOL EQUIPMENT AT OELWEIN, IA., C. G. W. RY.

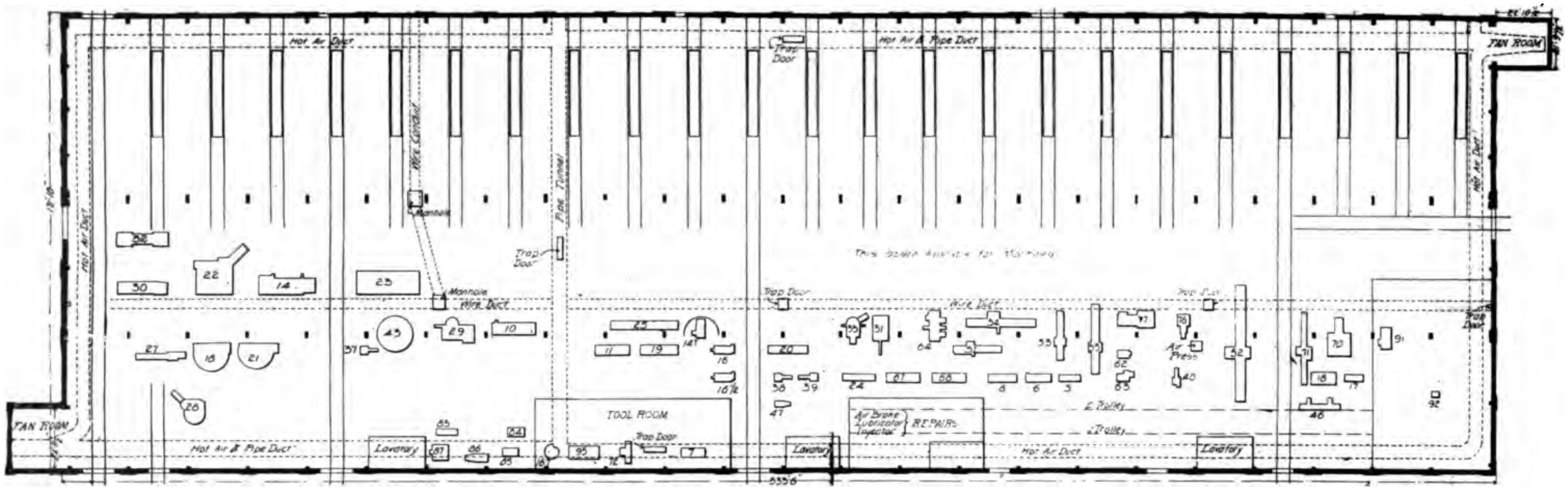
No.	Description.
1	Freight elevator.
2	Straightening plate.
3	Flange clamp.
4	Flange fire.
5	Power rolls, 8 to 10 h. p.
6	Punch and shears, 5 h. p.
7	Forges.
8	Flange punch, 2½ h. p.
9	Drill press.
10	Bevel shears.
11	Drill.
12	Rattle (under floor).
13	Flue saw.
14	Flue stand.
15	Annealer.
16	Furnace.
17	Flue welder.
18	Air swager.
19	Flue tester.
20	Double head bolt cutter.
21	Grindstone.
22	Cold saw, ½ h. p.
23	Screw press (hand).
24	Single head bolt cutter.
25	Double head bolt cutter.
26	Shaper, 1½ h. p.
27	Emery grinder, 1 h. p.
28	Guide grinder, 1 h. p.
29	Horizontal borer, 2 h. p.
30	30-in.x10-ft. lathe, 2 h. p.
31	Bench for rod work.
32	Drill press.
33	Racks.
34	Grinder.
35	Saw.
36	Small drill press.
37	Universal grinder, 1 h. p.
38	Tape grinder, ½ h. p.
39	Milling machine, 1 h. p.
40	Grinder, ½ h. p.
41	24-in.x10-ft. lathe, 1½ h. p.
42	Bench.
43	Cupboard.
44	72-in. wheel press, 7 h. p.
45	Quartering machine, 3 h. p.
46	Wheel lathe, 7 h. p.
47	Shaper, 1½ h. p.
48	Bench, general uses.
49	Bench, piston and cross head fitting.
50	36-in.x12-ft. 6 in. lathe, 2½ h. p.
51	Small drill press.
52	25-in.x18-ft. lathe, 1½ h. p.
53	30-in.x16-ft. lathe, 2 h. p.
54	Radial drill, 2 h. p.
55	18-in.x10-ft. lathe, ¾ h. p.
56	Centering lathe, 1 h. p.
57	20-in.x10-ft. lathe, 1 h. p.
58	60-in.x60-in.x20-ft. planer, 5 h. p.
59	36-in.x36-in.x12-ft. planer, 3 h. p.
60	26-in.x26-in.x6-ft. planer, 2 h. p.
61	Drill press, 1 h. p.
62	Slotter, 2 h. p.
63	Drill press, 1 h. p.
64	Grindstone.
65	Hydraulic press (hand).
66	Bench for link work.
67	Bench for eccentric strap work.
68	Bench for driving box fitting.
69	51-in. boring mill, 2 h. p.
70	Emery grinder, 1 h. p.
71	Turret screw machine, 1 h. p.
72	Stud lathe, 1 h. p.
73	Flat turret lathe, 1 h. p.
74	84-in. boring mill, 4 h. p.
75	Rack.
76	Brass lathe, ¾ h. p.
77	Brass lathe, ¾ h. p.



ARRANGEMENT OF ERECTING PITS IN LOCOMOTIVE SHOP AT DANVILLE, ILL., C & E. I. R. R.



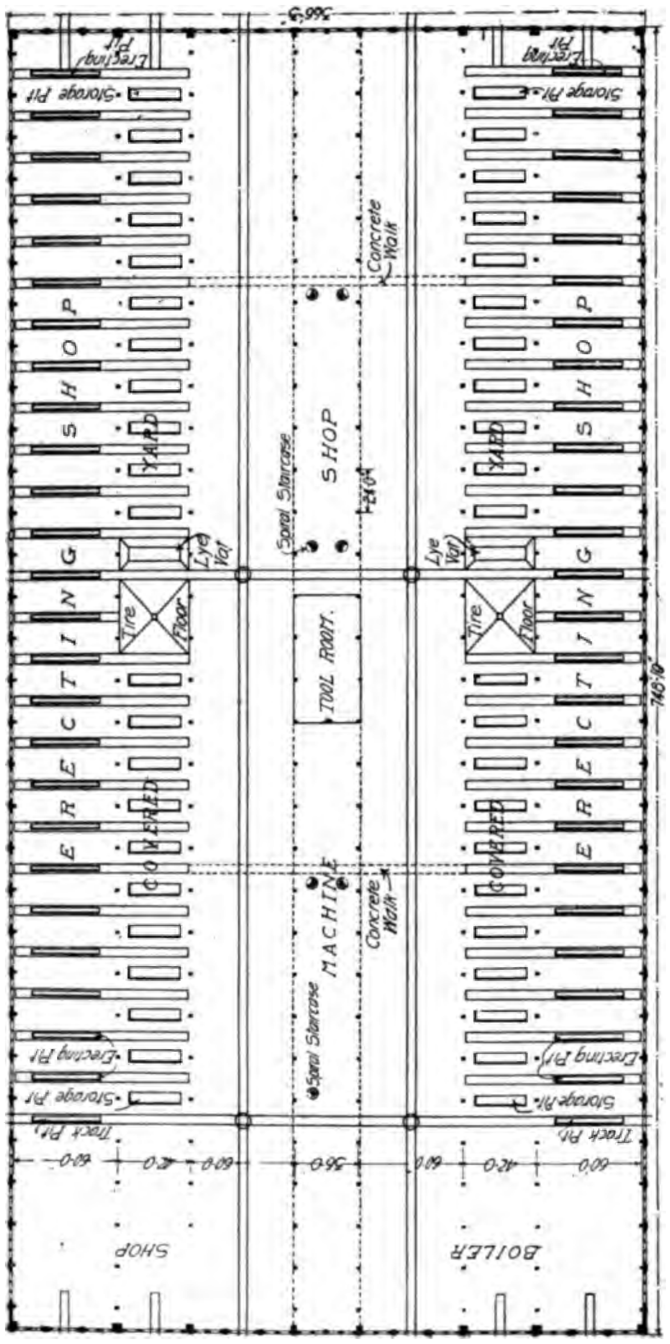
LAY OUT OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT DANVILLE, ILL., C. & E. I. R. R.—HEAVY MACHINE TOOLS ARE IN ERECTING BAY SERVED BY ERECTING FLOOR CRANE.



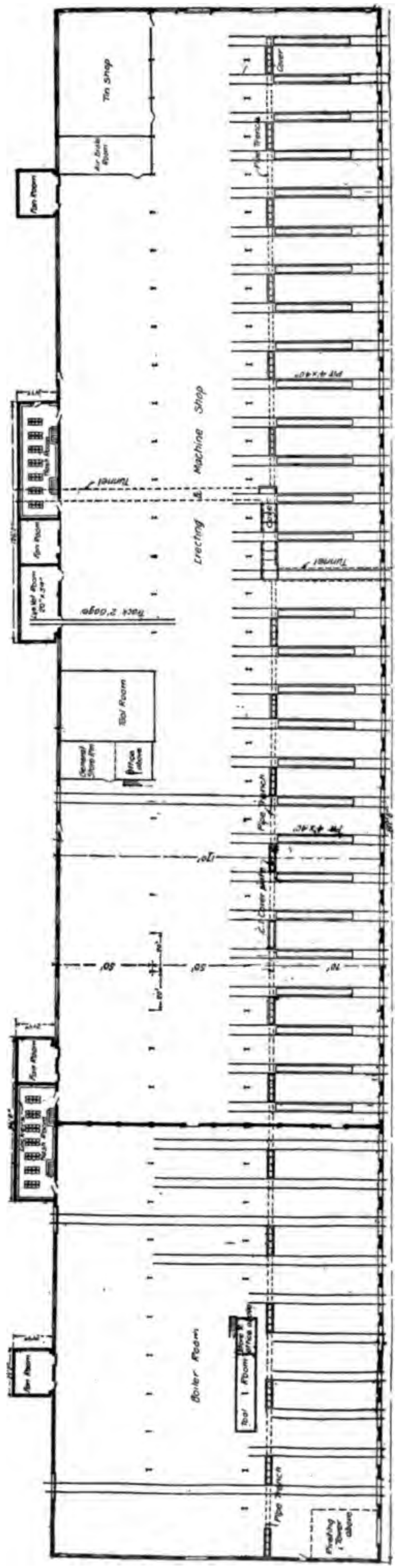
LAY OUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF PITS IN LOCOMOTIVE SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.

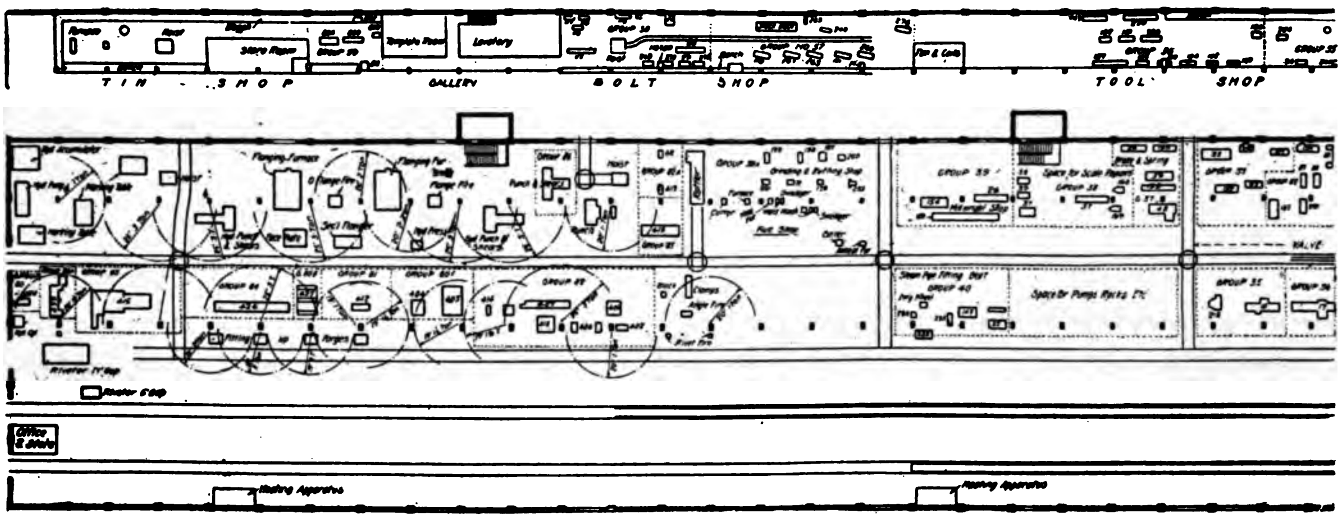
Mach. No.	Class of Machine.	Size.	Maker.	Motor H. P.
5	Lathe	18-in.	Flather	5
6	Lathe	20-in.	Reed	5
7	Lathe	20-in.	Reed	5
8	Lathe	25-in.	Putnam	7½
10	Lathe	42-in.	Niles	15
11	Lathe	24-in.	Reed	7½
13	Double Axle Lathe			25
14	Driv. Wheel Lathe	72-in.		25
16	Turret Lathe		Jones & Lamson	5
16½	Turret Lathe		Jones & Lamson	5
17	Brass Tur. Lathe			3
18	Brass Tur. Lathe	18-in.	Am. Tool & Mach. Co.	5
19	Lathe	24-in.	American	7½
20	Lathe	30-in.	Putnam	10
21	Double Head Axle Lathe		Putnam	35
22	Steel Tire Wheel Lathe		Pond	20
23	Driv. Wheel Lathe	90-in.	Putnam	25
24	Lathe	18-in.	Putnam	7½
25	Lathe	36-in.	Putnam	10
27	Wheel Press		Niles	7½
28	Car Wheel Borer		Pond	10
29	Boring Mill	72-in.	Pond	25
30	Wheel Press	100-in.	Putnam	7½
31	Horz. Bor. Mach.		Betts	15
32	Quartering and Pin Turning Machine		Niles	5
33	Vertical Bor'g and Turning Mill	51-in.	Baush	15
37, 38, 39, 40	Vertical Drill Presses			4
43	Radial Drill	6-ft.		4
45	Sensitive Drill			
46	Multiple Rod Drill		Bement	9½
47	Vert'l Drill Press	30-in. table	Snyder	5
51	Planer	30x30 in.x8 ft.		
52	Planer	60x60 in.x20 ft.	Pond	20
53	Planer	30x30 in.x8 ft.	Powell	7½
54	Planer	42x42 in.x15 ft.	Cincinnati	15
55	Planer	42x42 in.x12 ft.	Pond	15
62	Shaper	12-in.		5
63	Shaper	24-in.		7½
64	Shaper	24-in.	Cincinnati	7½
67, 68	Lathes	20-in.	Putnam	7½
70	Turret Lathe	34-in.	Gish^lt	15
71	Slab Miller			6½
72	Milling Machine			
76	Slotter	12-in.	Betts	6½
77	Slotter	19-in.	Putnam	13
83	Bolt Cutter			
84	Bolt Cutter			
85	Bolt Cutter			
86	Nut Tapper	6-spindle		
87	Staybolt Cutter	4 heads		
91	Pipe Cutter		Saunders	7½
92	Spec'l Pipe Cutter		Saunders	
93	Twist Drill Grinder			
95	Universal Grinder			
107	No. 1 Tool Grinder		Sellers	
108	Power Hack Saw			
147	Radial Drill	5-ft. radius		6½



FLOOR PLAN OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.



FLOOR PLAN OF LOCOMOTIVE SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.

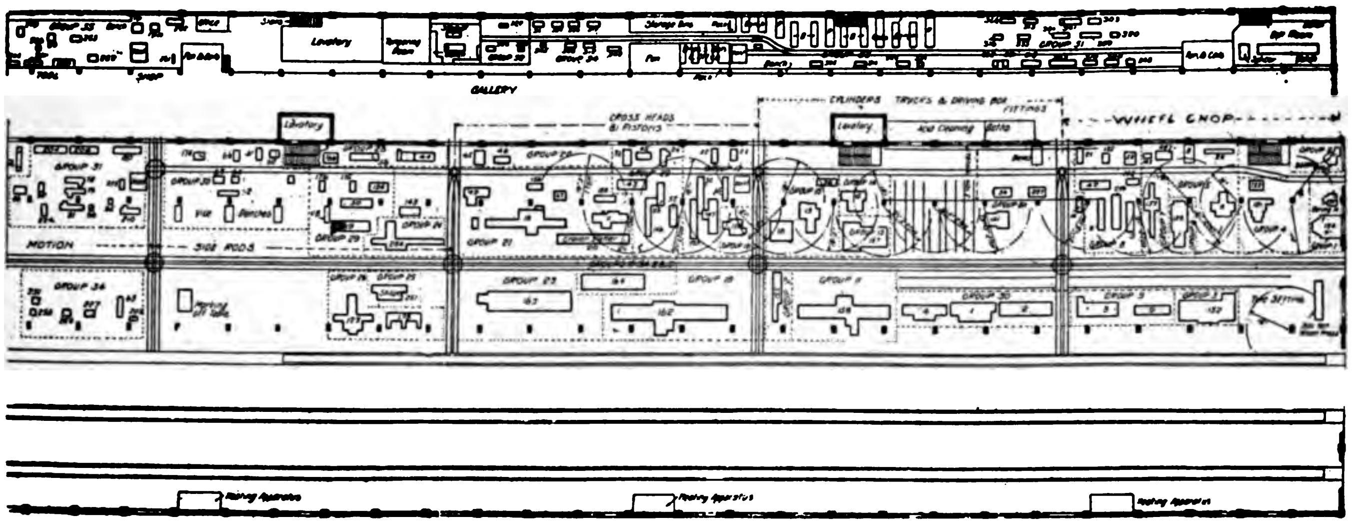


LAY OUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF PITS IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

Mach. No.	Class of Machine.	Size.	Maker.	
178	Side Rod Drill	3 Spindles	Bertram	
	Vertical Drill	36-in.	Bertram	20 A.C.
	Vertical Drill	24-in.		
123	Miller	5 ft.x5 ft.x12 ft.	Ingersoll	
251	Side Rod Shaper	24-in.—2 heads	Bertram	2-5 A.C.
284	Double Planer	4 ft.x4 ft.x14 ft.	Pond	15 A.C.
149	Turret Lathe	5-in.		2-2 A.C.
	Vertical Drill	40-in.	Bardons & Oliver	
19	Double Slotter	12-in. stroke	Bement Miles	
50	Double Drill		Bertram	20 A.C.
176	Vertical Drill	36-in.	Craven Bros	
184	Slotter	16-in.	Craven Bros	
44	Double Planer		Bertram	
56	Cotter Mill	4-Spindle		
166	Vertical Drill	40-in.	Bement Miles	10 A.C.
175	Vertical Drill	24-in.		
60	Shaper	12-in.	Bertram	
61	Shaper	24-in.	Bertram	
66	Crank Planer	18 in.x18 in.x18 in.	Craven Bros	
	Chucking Lathe	24-in.	Craven Bros	
64	Chucking Lathe	20-in.	Gardner	20 A.C.
62	Engine Lathe	16 in.x5 ft.x6 in.	Craven Bros	
63	Chucking Lathe	24-in.	Niles	
174	Turret Boring Mill	30-in.	McGregor	
	Engine Lathe	20 in.x5 ft	Bridgeport Co.	
	Suspended Emery Wheel	20-in.		
68	Side Bar Grinder		Bertram	
	Engine Lathe	12 in.x2 ft. 6 in.	Smith & Coventry.	
227	Link Grinder	5-ft. radius	Smith & Coventry.	
	Grindstone	6-ft.	Niles B. Pond	20 A.C.
236	Double Buffer	30 in.x8 in.	Niles B. Pond	
214	Emery Grinder	20-in. wheel	Can. Pac. Ry.	
	Lapping Lathe			
231	Grinder	Lea No. 1	Anderson T. Co.	2 small D.C.
81	Engine Lathe	24 in.x5 ft. 4 in.	M'Greg. & Gourlay	
224	Shaper	24-in.	Flather	
79	Engine Lathe	18 in.x5 ft.	Bertram	
78	Engine Lathe	16 in.x5 ft.	Gardner	
92	Shaper	4-in.		
206	Engine Lathe	24 in.x6 ft.	Bertram	
204	Engine Lathe	30 in.x8 ft. 6 in.	Bertram	
210	Engine Lathe	18 in.x3 ft. 6 in.	LeBlond	20 A.C.
95	Vertical Drill	20-in.	Craven Bros	
96	Vertical Drill	20-in.	Craven Bros	
225	Shaper	16-in.	Bertram	
	Centering Machine		D. E. Whiton	
	Engine Lathe	22 in.x8 ft. 6 in.		
86	Vertical Drill	36-in.	Craven Bros	
17	Planer	4 ft.x4 ft.x12 ft.	Flather	20 A.C.
	Vertical Drill	24-in.	Craven Bros	
88	Vertical Drill	36-in.	Craven Bros	
84	Planer	2 ft.x2 ft.x6 ft.	Bertram	
83	Planer	2 ft.x2 ft.x4 ft.	Craven Bros	
231	Vertical Drill	36-in.	Bertram	15 A.C.
183	Slotter	16-in.	Bertram	
87	Vertical Drill	36-in.	Bertram	
124	Engine Lathe	24 in.x5 ft. 6 in.	Gardner	
10	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	10 A.C.
218	Boring Mill	51-in.	Niles	

Mach. No.	Class of Machine.	Size.	Maker.	
93	Double Shaper	6-in.	Craven Bros	
182	Turret Lathe	3 in.x36 in	Pratt & Whitney	
	Turret Lathe	2 in.x24 in	A. Herbert	
217	Horz. Boring Mill	3-in. bar	Bement Miles	15 A.C.
200	Cutting-Off Mach.	5-in.	Bertram	
33	Hor. Boring Mach.		Craven Bros	
48	Radial Drill	5-ft.	Hulse & Co.	
192	Engine Lathe	24 in.x8 ft	Bertram	
59	Double Shaper	14-in.		10 A.C.
29	Engine Lathe	20 in.x5 ft		
190	Engine Lathe	30 in.x6 ft	Bertram	
	Vertical Drill	45-in.	Bertram	
168	Vertical Drill	36-in.	Bertram	
169	Vertical Drill	36-in.	Bertram	
59	Double Drill		Bertram	
	Screwing Machine	3-in.	Smith & Beacock	
	4 Spindle Drill	Up to ½ in.	Foote Burt	10 A.C.
37	Slotter	12-in.	W. Collier	
39	Slotter	10-in.	W. Collier	
38	Slotter	10-in.	W. Collier	
	Emery Grinder	20-in. wheel	Can. Pac. Ry	
189	Engine Lathe	24 in.x22 ft	Bertram	
26	Engine Lathe	24 in.x9 ft.	Smith & Coventry.	15 A.C.
154	Horz. Bor'g Mach.	4 in.x9 ft.	Bertram	
	Engine Lathe	18 in.x3 ft. 6 in.	LeBlond	
55	Vertical Drill	36-in.	Bertram	
285	Pipe Threader	10-in.	Cox & Sons	
235	Pipe Threader	4-in.	Williams Tool Co.	15 A.C.
286	Pipe Threader	4-in.	Armstrong	
	Emery Wheel	12-in.	Can Pac. Ry	
282	Emery Grinder	20-in. wheel	Can. Pac. Ry	
	Emery Grinder	20-in. wheel	Can. Pac. Ry	
	Tool Grinder	No. 2	Sellers	
111	Tool Grinder	No. 1	Sellers	
	Drill Grinder		Sellers	
	Tool Grinder		Cincinnati	
252	Universal Miller		LeBlond	
255	Vertical Drill	30-in.	Bertram	
250	Universal Grinder	No. 7	Landis	
99	Plain Miller		Bertram	20 A.C.
	Engine Lathe	22 in.x3 ft. 6 in.	LeBlond	
241	Engine Lathe	20 in.x4 ft. 6 in.	LeBlond	
244	Engine Lathe	14 in.x2 ft. 8 in.	Pratt & Whitney	
	Disc. Grinder	No. 1	Chas. Besly	
	Shaper	24-in.	Flather	
254	Vertical Drill	30-in.	Bertram	
	Tool Grinder	6-in. wheel		
94	Double Shaper	4-in.	Craven Bros	
100	Universal Miller	No. 3	Cincinnati	
	Turret Lathe	2 in.x24 in	Jones & Lamson	
109	Engine Lathe	16 in.x3 ft	Gardner	
105	Engine Lathe	14 in.x3 ft	Smith & Coventry.	
104	Engine Lathe	16 in.x2 ft		
108	Engine Lathe	16 in.x3 ft	Gardner	
103	Engine Lathe	16 in.x3 ft	Brown & Sharpe	
105	Engine Lathe	16 in.x4 ft. 6 in	Smith & Coventry.	20 A.C.
107	Engine Lathe	24 in.x10 ft	Bertram	
101	Engine Lathe	12 in.x3 ft	Smith & Coventry.	
243	Hack Saw		Patterson Tool Co.	
230	Engine Lathe	18 in.x9 ft	LeBlond	
102	Engine Lathe	10 in.x3 ft	Whitworth	
	Wet Grinder	42-in. wheel	Bridgeport	



LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF PITS IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

Mach. No.	Class of Machine.	Size	Maker.	
	Wheel Press	300 tons	Bertram	10 A.C.
134	Boring Mill	90-in.	Niles	20 D.C. / 2-5 D.C.
51	Boring Mill	51-in.	Bullard	10 D.C.
	Boring Mill	51-in.	Niles	7.5 D.C.
121	Boring Mill	64-in.	Bertram	
122	Car Wheel Borer			15 A.C.
28	Engine Lathe	30 in.x4 ft.	Pond	
145	Emery Wheel	20-in. wheels	Niles-Be't Pond	
132	Wheel Lathe	90-in.	Niles.....3 A.C. &	30 A.C.
8	Boring Mill	84-in.	Craven Bros	15 A.C.
9	Quarter'g Machine	90-in.	Bertram	2-5 A.C.
139	Planer	4 ft.x4 ft.x12 ft.	Bertram	20 .AC.
137	Horz. Miller	42 in.x42 in.x14 ft.	Bement Mills	20 D.C.
5	Axle Lathe			
259	Axle Lathe	14 in.x8 ft.	Bertram	
6	Axle Lathe			
140	Shaper	24-in. stroke	Niles	30 A.C.
42	Planer	32 in.x32 in.x8 ft.	Craven Bros	
135	Shaper	14-in. stroke	Craven Bros	
21	Boring Mill	37-in.	Niles	
14	Radial Drill	4-ft.		
3	Wheel Lathe	72-in.	Bertram	
2	Wheel Lathe	84-in.	German Niles	30 A.C.
1	Wheel Lathe	84-in.		
4	Wheel Lathe	60-in.	Bertram	
141	Slotter	20-in. stroke	Bertram	
287	Vertical Drill	50-in.	Bement Miles	10 A.C.
34	Slotter	14-in.	Craven Bros	

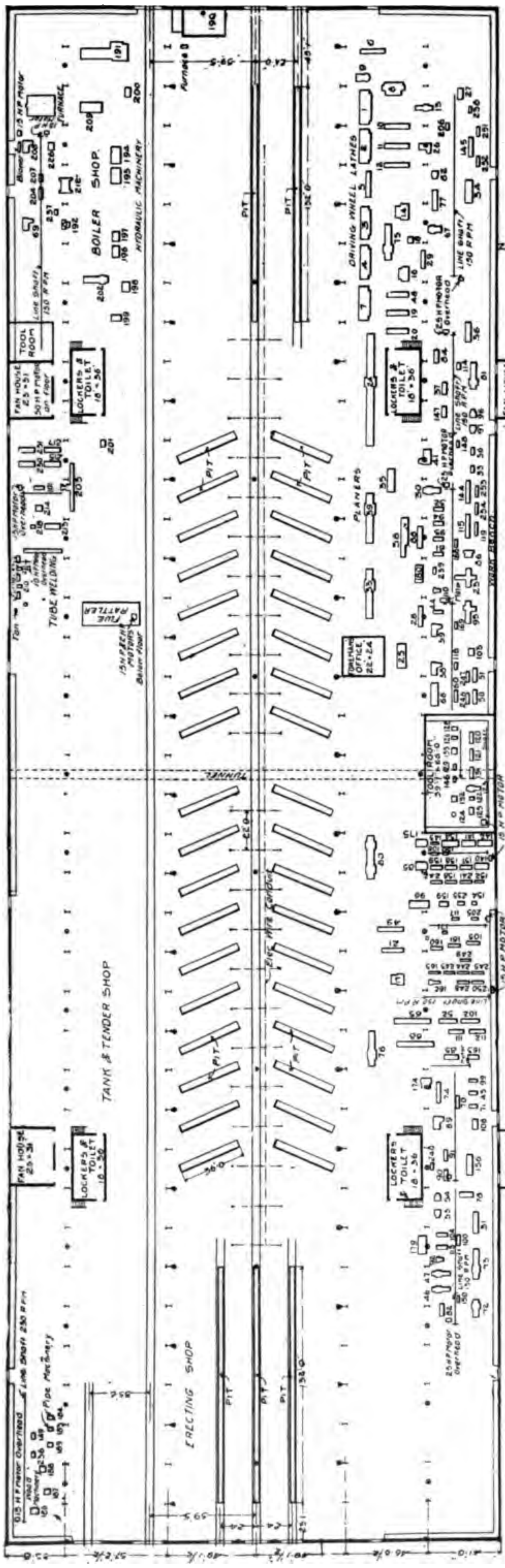
Cylinder and Frame Department.

Mach. No.	Class of Machine.	Size	Maker.	
158	Planer	6 ft.x6 ft.x22 ft.	Pond	30 A.C. / 5 A.C.
157	Radial Drill	9-ft.	Bement Miles	5 A.C.
15	Radial Drill	6-ft.	Bertram	5 A.C.
13	Planer	5 ft.x5 ft.x8 ft.	Sharp, Stewart Co.	
16	Cylinder Borer		Craven Bros	
36	Slotter	14-in. stroke	Newton	
	Engine Lathe	24 in.x5 ft.	Lodge & Shipley	30 A.C.
	Slotter for valve bush	5-in. stroke	Can. Pac. Ry	
155	Cylinder Borer	3 bars	Bement Miles	10 D.C.
150	Boring Mill	60-in.	Niles	10 D.C.
23	Chucking Lathe	30-in.	Craven Bros	
147	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	
193	Engine Lathe	36 in.x9 ft.x6 in.	Pond	20 A.C.
30	Engine Lathe	24 in.x7 ft. 6 in.	Bertram	
22	Chucking Lathe	30-in.	Craven Bros	
162	Planer, Frame	6 ft.x6 ft.x32 ft.	T. N. Shanks	20 A.C.
33	Chucking Lathe	36-in.	Craven Bros	
146	Engine Lathe	30 in.x10 ft.	Pond	
25	Engine Lathe	30 in.x6 ft.	Stewart	
43	Planer	32 in.x32 in.x8 ft.	Craven Bros	20 A.C.
24	Chucking Lathe	24 in.x4 ft.	Bertram	
45	Crank Planer	24 in.x24 in.x24 in.	Craven Bros	
52	Drill	36-in.	Craven Bros	

No. Mach.	Machine. Class of	Size.	Maker.	
164	4-Spindle Drill	For Frames	Bement Miles	4-5 D.C.
11	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	
88	Horz. Boring Mill	4 in. barx9 ft.	Binsse	
18	Planer	5 ft.x5 ft.x20 ft.	Bertram	
67	Vertical Miller	No. 6	Becker Brainard	30 A.C.
	Emery Grinder	20-in. wheel	Niles-Be't Pond	
49	Radial Drill	5-ft.	Hulse & Co.	
46	Shaper	24-in.	Flather	
165	Crank Planer	2 ft.x2 ft.x2 ft.	Craven Bros	10 A.C.
156	Cotter Drill	No. 3	Bement Miles	
163	Triple Slotter	24-in. stroke	Bertram	20 A.C.
20	Triple Slotter	8-in. stroke		10 A.C.

Brass Department.

No.	Machine.	Size.	Maker.	
348	Engine Lathe	12 in.x3 ft. 9 in.	Bertram	
343	Turret Lathe	24-in.	Am. Tool Co.	
335	Forming Lathe	18-in.	Warner & Swasey.	
300	Engine Lathe	20 in.x2 ft. 6 in.	Bertram	
309	Turret Lathe	24-in.	Smith & Coventry	
303	Turret Lathe	14-in.	Bertram	
310	Engine Lathe	24-in.x4 ft. 8 in.	LeBlond	
304	Turret Lathe	20-in.	Bertram	
341	Turret Lathe	22-in.	Bullard	
313	Turret Lathe	20-in.	Warner & Swasey.	20 A.C.
302	Valve Miller	2 Spindles	Warner & Swasey	
301	Chucking Lathe	15-in.	Smith & Coventry	
315	Chucking Lathe	15-in.	Smith & Coventry	
	Turret Lathe	16-in.	Smith & Coventry	
316	Turret Lathe	16-in.	Warner & Swasey.	
306	Turret Lathe	16-in.	Smith & Coventry	
	Emery Grinder	6-in. wheel	Can. Pac. Ry.	
320	Saw		Can. Pac. Ry.	
321	Valve Grinder		Warner & Swasey.	
344	Vertical Drill	30-in.	Bertram	
314	Forming Lathe	16-in.	Warner & Swasey.1	10 A.C.
305	Turret Lathe	1 in.x10 in.	Pratt & Whitney	
	Disc Grinder	No. 4	Charles Besly	
343	Sensitive Drill		Can. Pac. Ry.	
312	Speed Lathe	13-in.	Am. Tool Co.	
336	Turret Lathe	16-in.	Warner & Swasey.	
308	Speed Lathe	13-in.	Am. Tool Co.	
307	Turret Lathe	16-in.	Smith & Coventry	10 A.C.
	Turret Lathe	16-in.	Niles-B.-Pond	
317	4-Spindle Drill	To ½ in.	Foote Burt	
311	Turning Lathe	14-in.	Am. Tool Co.	
324	Buffer		Can. Pac. Ry.	
326	Buffer		Can. Pac. Ry.	
322	Buffer		Tacker Levett	20 A.C.
	Buffer		Dickerman	



LAY OUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS IN ERECTING SHOP AT SILVIS, ILL., C. R. I. & P. RY.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.

Mach. No.	Class of Machine.	Size.	Maker.	H.P. Motor.
1	Driving Wheel with Quart'r'g Attach.	79-in.	Niles	15
2	Driv. Wheel Lathe, Double Head	79-in.	Niles	15
3	Driv. Wheel Lathe, Double Head	69-in.	Niles	15
4	Driv. Wheel Lathe, Double Head	69-in.	Niles	15
5	Hydraulic Wheel Press	84-in.	Chicago Shops	10
6	Hydraulic Car Wheel Press	42-in.	Niles	5
7	Driv. Wheel Lathe	90-in.	Chicago Shops	15
8	Steel Tire Car Wheel Lathe	42-in.	Pond	10
9	Car Wheel Boring Machine	42-in.		5
10	Locomotive Axle Turning Lathe			15
11	Double Axle Lathe			15
12	Single Axle Lathe			10
13	Horz. Milling Mach. for Keyways		Beaman & Smith	
14	Double Head Vertical Bor'g Mach.	84-in.		10
16	Double Head Boring Machine	72-in.		10
17	Double Head Boring Machine	60-in.		7½
18	Key Seater Mach.	No. 3	Grant, Mitts & Mer.	
19	Engine Lathe	32 in.x12 ft.		5
20	Engine Lathe	32 in.x12 ft.		5
21	Engine Lathe	32 in.x14 ft.		5
22	Portable Crank Wheel Press		Watson & Stillman.	
23	Duplex Mill'g Mch.		Beaman & Smith	
24	Double Head Frame Planer	54 in.x34 ft.		20
25	Horizontal Boring Machine	No. 4	Bement	
26	Radial Drill Press.	5-ft.	Niles	
27	Drill Press	40-in.	Aurora	
28	Double Shaping Machine	20 in.x12 ft.	Bement	
29	Double Shaping Machine	20 in.x12 ft.	Bement	
30	Planer	30 in.x30 in.x6 ft.		
31	Engine Lathe	30 in.x12 ft.	Chicago Shops	
32	Pillar Shaper	30-ft.	Cincinnati	
33	Cylinder Planer	60 in.x60 in.x16 ft.	Chicago Shops	20
34	Slotter	24-in.	Chicago Shops	
35	Slotter	18-in.	Bement	15
36	Slotter	18-ft.	Niles	
37	Drill Press	40-ft.	Aurora	
38	Locomotive Cylinder Borer		Bement	10
39	Locomotive Cylinder Planer	72 in.x84 in.x16 ft.		27½
41	Radial Drill, with Tapping Attach.	72-in.	Niles	
43	Portable Valve Seat Miller			
44	Draw Stroke Shaper	24-in.	Morton	
45	Draw Stroke Shaper	30-in.	Morton	
46	Planer	30 in.x30 in.x6 ft.		
47	Planer	30 in.x30 in.x6 ft.		
48	Triple Geared Lathe	36 in.x12 ft.		5
49	Triple Geared Lathe	36 in.x14 ft.		5
50	Back Geared Engine Lathe	18 in.x8 ft.	Lodge & Shipley	
51	Back Geared Engine Lathe	18 in.x8 ft.	Lodge & Shipley	
52	Back Geared Engine Lathe	18 in.x10 ft.	Lodge & Shipley	
53	Double Head Vertical Bor'g Mill.	37-in.	Niles	
54	Double Head Bortical Bor'g Mill	37-in.	Niles	
55	Vert. Turret Bor'g and Turn'g Mch.	30-in.	Niles	
56	Vert. Turret Bor'g and Turn'g Mch.	30-in.	Niles	
57	Radial Drill	60-in.	Niles	
58	Radial Drill	60-in.	Niles	
59	Drill Press	40-in.	Aurora	
61	Pillar Shaper	24-in.	Cincinnati	
62	Double Head Vert. Boring Mill	37-in.	Niles	
65	Engine Lathe	46 in.x16 ft.		
66	Horz. Drilling and Boring Machine.	No. 2	Bement	
67	Planer	36 in.x36 in.x8 ft.	Bement	
68	Engine Lathe	42 in.x16 ft.		
70	Drill Press	40-in.	Aurora	
71	Shaper	24-inch.	Cincinnati	
72	Planer	30 in.x30 in.x9 ft.		
73	Planer	30 in.x30 in.x16 ft.		
74	Engine Lathe	24 in.x12 ft.		
75	Planer	48 in.x48 in.x12 ft.	Pond	15
76	Planer	48 in.x48 in.x12 ft.	Pond	15
77	Engine Lathe	24 in.x12 ft.		
78	Guide Bar Grinde-	84-in.	Springfield	
79	Portable Wrist Pin Machine		Pedrick & Ayer	
80	Rod Planer	38 in.x38 in.x18 ft.	Niles	15

81	Planer	38 in.x48 in.x12 ft.		
82	Slotter	14-in.	Niles	
83	Slotter	14-in.	Niles	
84	Slotter	14-in.	Niles	
85	Drill Press	50-in.	Niles	
86	Universal Milling Machine	No. 3	Becker-Brainerd	
87	Portable Bushing Press	20-Ton	Watson & Stillman.	
88	Back Geared Engine Lathe	32 in.x12 ft.	Pond	
89	Radial Drill	60-in.	Niles	
90	Drill Press	40-in.	Aurora	
91	Drill Press	40-in.		
92	Planer	24-in.	Bement	
93	Shaper	24-in.	Cincinnati	
94	Shaper	24-in.	Cincinnati	
95	Vertical and Horz. Milling Machine.	No. 2	Beaman & Smith	
96	Boring Mill	37-in.		
97	Boring Mill	37-in.		
98	Swing Gap Lathe.	58 in.x27 in.x 12 ft.	Putnam	
99	Shaper	24-in.	Cincinnati	
100	Drill Press	40-in.	Aurora	
102	Engine Lathe	20 in.x10 ft.	Lodge & Shipley	
103	Vertical Milling Machine	No. 5	Becker	
104	Shaper	24-in.	Cincinnati	
105	Screw Machine	2 in.x24 in.	Jones & Lamson	
106	Drill Press	21-in.	Hoefer	
108	Universal Grinding Machine	No. 1		
110	Crank Planer	24-in.	Bement	
111	Compound Shaper.	28 in.x8 ft.		
112	Compound Shaper.	28 in.x8 ft.		
113	Shaper	24-in.	Cincinnati	
114	Drill Press	21-in.	Cincinnati	
115	Engine Lathe	24 in.x12 ft.		
117	Drill Press	21-in.	Hoefer	
118	Drill Press	21-in.	Hoefer	
119	Engine Lathe	16 in.x6 ft.	Lodge & Shipley	
120	Tool Room Lathe.	14 in.x6 ft.	Pratt & Whitney	
121	Tool Room Lathe.	14 in.x6 ft.		
122	Shaper	16-in.	Gould & Eberhart	
123	Planer	24 in.x24 in,x5 ft.		
124	Universal Tool Grinder		Horton	
125	Universal Milling Machine	No. 3	Hendey	
126	Twist Drill Grinder		Yankee	
128	Tool Grinder.		Gisholt	
129	Drill Press	21-in.	Hoefer	
130	Frict'n Drill Press.		Barnes	
131	Tool Room Lathe.	10 in.x5 ft.	Pratt & Whitney	
132	Universal Grinder.	No. 1		
133	Double Wet Grinder for Tool	No. 3	Springfield	
134	Brass Tur Lathe	24 in.x8 ft.		
137	Sq. Arbor Lathe.	15 in.x6 ft.		
138	Sq. Arbor Lathe.	15 in.x6 ft.		
139	Brass Lathe	17 in.x6 ft.		
140	Brass Tur. Lathe.	17 in.x6 ft.		
141	Brass Tur. Lathe.	18½ in.x6 ft.		
142	Brass Tur. Lathe.	18½ in.x6 ft.		
143	Valve Milling Machine	No. 1	American	
144	Engine Lathe	28 in.x12 ft.		
145	Engine Lathe	22 in.x10 ft.		
146	Frict'n Drill Press.		Barnes	
147	Drill Press	32-in.	Aurora	
148	Drill Press	21-in.	Hoefer	
150	Drill Press	21-in.	Hoefer	
151	Oil Separator	No. 1	American	
152	Two-spindle Centering Machine.		Whiton	
154	Buffing Lathe	No. 3		
156	Planer Grinder	26-in.	Landis	
158	Engine Lathe	14 in.x6 ft.	Lodge & Shipley	
159	Disk Grinder	No. 6	Norton	
160	Turret Lathe	2 in.x26 in.	Pratt & Whitney	
161	Turret Lathe	2 in.x26 in.	Pratt & Whitney	
162	Turret Lathe, Gisholt	21-in.	Hoefer	
163	Drill Press	21-in.	Hoefer	
165	Bolt Lathe	14 in.x5 ft.	Bradford	
168	Drill Press	25-in.	Hoefer	
171	Frict'n Drill Press.		Barnes	
174	Boring Mill	60-in.	Niles	
175	Drill Press	50-in.	Niles	
179	Radial Drill	72-in.		
180	Radial Drill	72-in.		
235-240	Double Emery Wheel Grinders.	No. 6	Diamond	
241-247	Engine Lathe.	16 in.x6 ft.	Lodge & Shipley	
248-254	Engine Lathe.	14 in.x6 ft.	Lodge & Shipley	
169	Radial Drill	60-in.	Niles	
101	Drill Press	28-in.	Aurora	
149	Drill Press	21-in.	Hoefer	
183	Pipe Machine	1-in. to 2-in.	Jarecki	
184	Pipe Machine	1½ in.x4 in.	Forbes	
186	Band Saw	36-in.	Carse	
187	Combined Rip and Cut-off Saw			
188	Hand Joiner		Fay	
189	Single Spindle Vertical Borer	No. 2		
190	Hydraulic Riveter.	17-ft.	Bement	
191	Bending Rolls	14-ft.	Niles	40
192	Rotary Bevel Shear		Lenox	
194	Hydraulic Punch	60-in.	Bement	
195	Hydraulic Shear	54-in.	Bement	
196	Hydraulic Die Block Punch	36-in.	Bement	
197	Hydraulic Punch.	25-in.	Bement	
198	Hydraulic Angle Shear		Bement	
199	Hydraulic Universal Shear		Bement	
200	Hydraulic Horiz. Flange Punch		Bement	
201	Quick-Acting Hydraulic Punch	20-in.		
202	Bending Rolls	86-in.	Niles	10
203	Power Punch with Spacing Table	28-ft.	Hilles & Jones	
204	Drill Press	40-in.	Aurora	
205	Drill Press	25-in.	Hoefer	
206	Drill Press	21-in.	Hoefer	
207	Drill Press	21-in.	Hoefer	
208	Radial Drill with Tapping Atch	60-in.	Niles	
209	Hydraulic Flanging Press, Sectional		Bement	
210	Flue Welder		Ferguson	
211	Flue Welder		Ferguson	
212	Four Spindle Flue Sheet Drill		Niles	
213	Bolt Cutter	4-in.	Acme	
214	Triple Bolt Cutter	1-in.	Acme	
215	Double Bolt Cutter	1½-in.	Acme	
173	Six Spindle Arch Bar Drill		Niles	
176	Forging Hammer.	200 lbs.	Bradley	
177	Forging Hammer.	200 lbs.	Bradley	
178	Forging Hammer.	200 lbs.	Bradley	
181	Bolt Header	1-in.	Ajax	
182	Bold Header			
216	Hydraulic Bar Shears	2-ft. diam.	Bement	
217	Double Bolt Cutter	1½-in.	Acme	
218	Bolt Pointer		Acme	
219	Forging Machine	No. 3	Acme	
220	Long Stroke Steam Hammer	1,600 lb.	Chambersburg	
221	Single Stand Steam Hammer	1,500 lb.	Chambersburg	
222	Single Stand Steam Hammer	1,500 lb.	Chambersburg	
223	Hydraulic Bar Shears	1¼ in.x12 in.	Bement	
224	Hydraulic Punch and Shear	20-in.	Bement	
225	Bolt Header	1½-in.	Acme	
226	Cold Saw		Hegley-Cambria	
227	Double Stand Steam Hammer.	5,000 lb.		
228	Single Stand Steam Hammer	1,100 lb.		
229	Single Stand Steam Hammer.	1,000 lb.		
230	Double Staybolt Cutter	1½-in.		
231	Double Staybol Cutter	1½-in.		
232	Hammer Riveter	84-in.	Allen	
233	Portable Mud Ring Riveter		Pedrick & Ayer	
234	Portable Pneumatic Riveter		Pedrick & Ayer	
173	Six Spindle Arch Bar Drill			
181	Bolt Header	1-in.	Ajax	
182	Bolt Header	1-in.	Ajax	

Railway Shop Up To Date

Chapter IV

BLACKSMITH SHOP

LOCATION.

THE location of the blacksmith shop is an essential feature not only as influencing the design and arrangement of the building, and the layout of the tools, hammers, forges, etc., but also as affecting the output of the shop. The nature of the work and the conditions surrounding it, require the building to be in an isolated location in order to provide light and air on all sides. In repair work much material travels from the erecting and assembling shops to the blacksmith shop and back again, especially in locomotive work. A large proportion of the material passing between the locomotive and blacksmith shops is heavy and bulky. For this reason the blacksmith shop should be so situated in relation to the locomotive department as to provide for movement over the shortest and most direct route. Such material is usually transported on push cars and trucks so that distances are important in economizing time and increasing output.

With the increased use of forging machines and the general introduction of time and labor saving devices for rapidly forming parts entering into car construction, a large volume of material is delivered to the car department, especially where the construction of new cars is carried on. This material is principally in small pieces; but includes a large number of the same kind and methods of rapid production must be supplemented by efficient means of quick distribution.

From the standpoint of shop production the blacksmith shop is looked upon as a feeder for the other shops. Of prime importance, then—though sometimes overlooked in preparing original plans—is the provision for feeding the blacksmith shop. The blacksmith shop at the principal shop plant of a large railway system turns out the forgings entering into the construction of new cars, the bulk of the car forgings required in keeping up the repairs of both freight and passenger car equipment on the line, as well as the forgings for locomotive repairs and on some systems a certain amount of switch and frog work, together with other repair work for the road department.

While in one building, it is very common practice to separate the work for the locomotive and car departments and place each under the jurisdiction of an individual foreman. As there is a difference in the nature of the work for the two departments, each occupies a section common to itself and the machines, forges and equipment are arranged accordingly. Naturally the equipment for each department is situated in that portion of the blacksmith shop building nearest to the principal shop which it serves.

LAYOUT.

A ground plan in the shape of an L is a convenient arrangement for the blacksmith shop accessible to both the locomotive and car departments, and such a form has been used in several places as at Angus, Collinwood and Burnside. Large hammers with their furnaces are located in the end of the building nearer the locomotive shop, while the open fires occupy convenient positions, and bolt headers, shears, upsetting and forging machines, etc., are placed to provide for rapid movement of finished material to the car department.

In shops of the ordinary rectangular form, the layout of equipment is arranged on the same principle. For instance at South Louisville, on the Louisville & Nashville Railroad, the blacksmith shop is parallel with and next to the locomotive shop. The yard crane passes one end of the shop and the freight car repair shop is parallel to this end, beyond the yard served by the crane. Here the equipment for car department work is in the end adjacent to the crane runway to provide for rapid intake and delivery, while the heavy hammers, etc., for locomotive work are at the other end of the shop and are accessible from the locomotive shop.

SIZE OF SHOP.

The many conditions affecting the demands upon the blacksmith shop and the difference in the dimensions of the shops on the various railway systems, render it impractical to attempt to give a definite proportion based upon any given unit. The introduction of cast steel in many details for which forgings were formerly used almost entirely, has affected the necessary size of the blacksmith shop so far as the locomotive department is concerned and the increased scope of forging machines, assisted by the extended use of formers and dies for rapidly duplicating standard parts of cars, has increased the possible output of car forgings without enlarging the area required by the shop building.

The dimensions of several prominent shops will in some measure serve as a guide for others where conditions may be expected to be somewhat similar. In this connection it is worthy of note that in several instances the building for the blacksmith shop is partially given over to some other work, in some cases for temporary work or until the enlargement of principal departments increases the demands on the blacksmith shop. At Silvis one end of the blacksmith shop is used as a brass foundry. At Collinwood a brass foundry and a bolt shop are included within the smith shop building. The spring shop frequently occupies a portion of the smith shop,

though a small, individual building is sometimes built for this work exclusively.

For both car and locomotive work, the smith shop at Topeka, A. T. & S. F. Ry., is 400 feet by 100 feet, providing an area of 40,000 square feet. At Angus, C. P. Ry., where much freight car building is done in addition to locomotive repairs and the construction of new passenger cars, the area is approximately 84,200 square feet. One wing of the building is 303 feet by 146 feet and the other 303 feet by 130 feet. At Danville, C. & E. I. R. R., the smith shop is 136 feet by 100 feet, an area of 13,600 square feet. At Elizabethport, C. R. R. of N. J., the dimensions are 300 feet by 82 feet, an area of 24,600 square feet. At Silvis, C. R. I. & P. Ry., the building is 465 feet by 99 feet and with 85 feet used as a brass foundry, the area of the smith shop is approximately 33,000 square feet. At Collinwood, L. S. & M. S. Ry., the area of the smith shop proper is approximately 25,000 square feet. While not as large as the shop at Angus, yet greater than the average, the area at South Louisville, L. & N. R. R., is approximately 60,000 square feet. The blacksmith shop at McKee's Rocks, P. & L. E. R. R., contains about 14,000 square feet.

CONSTRUCTION.

The construction of blacksmith shops on different railway systems varies principally in the span of roof trusses between side walls, the design of the roof structure and the form of the roof for the disposition of smoke. The walls are usually of brick, though at Elizabethport the walls are of concrete and at Topeka the ends of the building above the windows are enclosed with corrugated galvanized iron supported by steel framing.

A very general practice has been to span the entire floor without providing intermediate supports for the roof trusses and in a number of cases this distance equals 100 feet. The trusses are usually supported by the side walls which carry the weight of the roof structure and roof. At Topeka the steel skeleton is entirely independent and the roof structure is carried by built up steel columns, to which the walls are secured to provide stability. The roof trusses span a distance of 100 feet.

The elimination of supporting columns and the long span of roof trusses without intermediate supports, allows a free scope in the distribution of equipment on the floor. The method of handling heavy work in the blacksmith shop by means of swinging jib cranes requires freedom of action for the crane arms and the absence of obstructions facilitates the arrangement of these cranes.

The long span of roof trusses together with the requirement of a stiff frame construction to withstand the additional load imposed by supporting the upper ends of the crane columns, calls for heavy parts and careful design of the roof structure. The horizontal loads imposed by the swinging jib cranes, require stiff lateral bracings. Good design to meet these requirements are particularly noticeable at Topeka and Collinwood.

In some shops of recent construction, and at others not yet completed, the shop is divided into three bays, or sections, by two rows of columns supporting the roof structure. Such an arrangement prevails at Angus, South Louisville and Beech Grove (Indianapolis, Big Four). The central bay is narrower than the other two.

DOORS FOR DISTRIBUTION OF MATERIAL.

A very essential feature in the construction of the blacksmith shop, especially where a large amount of work is done for freight car construction, is a provision for a large number of doors in the walls toward the storage yard, in addition to the usual doors for the delivery and distribution of material.

By providing such doors at intervals of a few yards, raw material may be so stored that it will be easily accessible to the several machines through which it will pass in the process of manufacture. Through these doors it will travel over the shortest and most direct route and workmen consume minimum time in securing material for their work.

HEIGHT FROM FLOOR TO ROOF TRUSS.

While the distance from the floor to roof trusses at some of the older shops is about 20 feet, there is a decided tendency to increase this height, noticeable at the prominent shops of recent design and a height of 28 feet has been recommended. The actual dimensions of a number of shops are instructive. At Elizabethport, C. R. R. of N. J., the height of bottom of roof truss above floor of blacksmith shop is 20 feet; at Sedalia, Mo., M. P. Ry., this height is 22 feet; at Collinwood, L. S. & M. S. Ry., 24 feet; at Danville, C. & E. I. R. R., 24 feet; at Silvis, C. R. I. & P. Ry., 25 feet 6 inches; at McKees Rocks, P. & L. E. R. R., 25 feet 9⅜ inches; at Topeka, A. T. & S. F. Ry., 30 feet.

At South Louisville, L. & N. R. R., the bottom line of roof trusses is 35 feet 3 inches above the floor of the central bay, while this distance in the side bays is 20 feet. At Angus, C. P. Ry., this distance is 32 feet and 20 feet in the center and side bays respectively. At Beech Grove the central bay is to have a clear height of 38 feet.

FLOOR.

Almost without exception, the floor of a blacksmith shop is of earth of some kind. This is frequently covered with a coating of cinders well tamped, or with clay.

CRANE SERVICE.

With few exceptions, crane service in blacksmith shops has been confined almost entirely to the use of swinging jib cranes. The impression has prevailed that there is not sufficient service for a traveling crane to justify the cost of its installation and maintenance and the amount of smoke and gas present in some blacksmith shops would make it very uncomfortable for an operator of an overhead crane.

In later years, however, the use of traveling cranes has gained in favor and improved ventilation has rendered it more practical. The entire floor of the blacksmith shop of the Philadelphia & Reading Railroad at Reading, is served by an overhead traveling crane and the central bay of the shop at South Louisville is served by one of 10 tons' capacity. In order that the crane operator may suffer no discomfort from the effect of gases that might accumulate near the roof, the cage for the crane operator at South Louisville is only 10 feet above the [illegible] central bay of the smith shop at Beech [illegible] also is to be served by a traveling cra[illegible] pacity.

VENTILATION AND LIGHT.

The ventilation necessary in a blacksmith shop and the amount of natural light needed, require a high, free space not only to allow the smoke and gas to rise away from the floor, and forges but to permit the wide diffusion of light from long windows. It is a very noticeable fact that the cleanest, brightest and most airy blacksmith shops are those with high walls. Without criticism of the appearance of other shops, the condition always to be found in the blacksmith shops of the New York Central at Depew and the P. & L. E. at McKees Rocks, is particularly commendable.

While the roof of the blacksmith shop is usually surmounted by a wide monitor extending nearly the entire length of the roof, this is provided for the sake of ventilation rather than to distribute light. The windows in the walls are depended upon principally for natural light and it is generally considered that the window area should equal at least sixty per cent of the wall area.

In order to offer least obstruction to the free circulation of air throughout the shop in warm weather and in warm climates, when it is desired to have the windows open, it is very common for at least some of the sashes in each window, usually at or near the top, to be hung on pivots. A greater opening is thus provided than by merely raising and lowering the sashes. At South Louisville all sashes of the windows in the side walls are hung on pivots.

At some shops the roof is built with a high pitch and a comparatively narrow monitor, while at others the roof is almost flat with a wide monitor. Where the building is divided into three sections by two rows of columns supporting the roof structure, the roof of the central section is higher than the roofs of the side sections and the higher roof is surmounted by a monitor of ample dimensions. Windows above the roofs of the side sections admit light to the central section and aid in ventilation.

An arrangement frequently followed in the construction of the monitor is to alternate the windows along the sides with spaces having wooden slats built in on an angle, thus permitting the circulation of air while excluding rain or snow. The entire length of both sides of the monitor is sometimes equipped with glass sashes. In some cases all of the sashes are hung on pivots and in others alternate sashes are permanent and those between are pivoted.

HAND FORGES.

Hand forges are usually arranged in a row along the wall, placed conveniently according to the class of work which they serve. The distance between centers of forges varies from 14 to 16 feet and 15 feet is a very common spacing. A spacing of 18 feet between centers of forges has been used successfully for heavy locomotive work, and it is believed that this distance will become more common in shops of the future. In the case of single forges a distance of 5 feet from wall to center line of forges is considered ample, with a free space of about 20 feet from the center line toward the interior of the shop for working room. This gives an area of about 375 square feet per forge.

The arrangement of the forges in the blacksmith shop of the P. & L. E. at McKees Rocks is a good example of the use of double forges. Here, a row of double forges is situated on a center line 15 feet from the wall and each forge is placed at an angle of 54 degrees with this line. They are spaced 15 feet between centers and an area 20 feet wide from the center line of the forges toward the interior of the shop is allowed for working room. Such an arrangement provides a working area of 525 square feet for each double forge or about 262 feet for each fire. In addition to the floor space gained, this arrangement has the further advantage of reducing the number of stacks and holes in the roof by one half, where hoods are used over the forges. Forges are arranged at uniform height, say about 24 inches and are usually of uniform shape and size.

Careful provision for tool racks is a necessary detail not to be overlooked, for while the care and maintenance of tools and equipment is the duty of the energetic foreman, it is within the province of the designer to prepare for maximum output by providing for such seemingly minor details as well as for the larger details.

The removal of smoke and gases from the forges is provided for by different methods. In some shops the air supply and exhaust are carried in underground ducts and placing the forges in groups of four simplifies the arrangement. Individual exhaust connections from the forges lead into a main duct and smoke and gases are discharged by fans through short stacks above the roof.

In other shops each forge is served by the ordinary hood with a stack extending through the roof, or one stack serves two forges placed back to back. It is not uncommon for blast pipes to be carried along the wall with individual leads between the main blast pipe and the several forges. The equipment, then, is all above ground and is accessible at all times.

At still other shops there are no hoods or stacks over the forges and all smoke and gas is expected to pass out of the building through windows in the sides of the monitors and through ventilators above the monitors. The experience at some shops, where great care was used in their design to provide for efficient ventilation, is said to have proved that smoke hoods are unnecessary and that the interior of the building is clear and free from smoke and gas at all times.

FUEL FOR FURNACES.

Oil is the most common fuel used in blacksmith shop furnaces. In later years it has rapidly displaced coal and coke, not only proving more satisfactory and economical as a fuel, but it improves the appearance of the shop by removing the necessity of unsightly coal and coke boxes about the shop. Comparative costs of coal and coke for fuel as against oil depends upon the locality in which the shop is situated. It has been demonstrated by practice that with oil as fuel it is possible to obtain a larger output, better grade of work, greater intensity of heat, as well as a more even heat, to eliminate the necessity of attending to fires, to shorten the time required to bring the furnace to the desired working temperature and to improve the conditions under which furnace men work.

It is worthy of note that at the Altoona and Juniata

shops of the Pennsylvania Railroad, the furnaces for heavy work burn gas as fuel and a gas producer plant is operated in connection with the blacksmith department at each of these points.

FURNACE EQUIPMENT.

It is a noticeable fact that in a majority of the new shops particular attention has been paid to the furnace equipment, the design of the various furnaces for the various machines and their location in relation to the machines and movement of material.

No part of the general railroad repair plant has undergone a greater change during the past ten or fifteen years than the blacksmith shop, for the reason that, whereas, a few years ago a majority of the work passing through that shop was done on open fires and a large quantity of the new material was purchased from manufacturing concerns, today, due to the introduction of forging machinery, a majority of the work in the new shop is, or should be machine work.

The output of the machines using heated material being primarily governed by the rapidity with which the material can be furnished has led to careful consideration of the shop furnace proposition. Properly designed oil furnaces occupy approximately 50 per cent less shop space than coal or coke furnaces, and, due to the absence of coal or coke bins, trucking of coal to or ashes from blacksmith shop, permit of almost ideal arrangement of the tools and furnaces, and a good economical movement of raw material to the machines and finished material to storeroom.

In machine blacksmithing it is very important that the material be heated in a nice, soft, reducing heat, as excess scale or oxidation is detrimental to good die work and hard on the dies. Furnaces should be designed to meet the particular requirements of each class of machines, so that the maximum output may be obtained, the operation of the furnaces may be as economical as possible, and as nearly as possible ideal shop conditions for the machine operators prevail.

BLAST.

In connection with furnace equipment and open fires particular attention should be paid to the layout of blast piping. Efficient blast is a very important consideration to the blacksmith shop, as it practically governs the heating capacity not only of the furnaces but of the open fires. Where blast is inefficient, not only are the fires and furnaces poor heaters but combustion is poor owing to the tendency of the men to crowd the fires and furnaces, and poor blast conditions make an expensive proposition generally. A majority of the new shops are furnishing blast to open fires and furnaces at a velocity equal to about 8 or 9 ozs.

In laying out blast lines it is very important that main delivery pipe be of sufficient size not only to supply the required tuyere area, but also to take care of some future extensions. Otherwise it is necessary to resort to the expensive practice of speeding up the fan equipment. Bends in blast piping should be calculated so as to give the least frictional resistance. Several of the new shops have had considerable difficulty due to extreme frictional losses in their blast systems.

ARRANGEMENT OF EQUIPMENT.

Properly grouping machines and equipment minimizes the expense of manufacture and repair by reducing the extent to which it is necessary to handle material. Bolt headers, forging machines, bolt cutters, are grouped near together and the punches and shears are situated conveniently to the headers as well as to the bulldozers and belt hammers. In locating machines care is required in providing ample space not only for working room about the individual machine, but also for tracks to provide for the movement and delivery of material.

The classes of work done in the blacksmith shop require the use of steam hammers varying in size from 800 pounds to 6,000 pounds. The equipment to serve each hammer depends on the class of work to which it is devoted and the extent to which it can be kept in continual service. In some instances a single large furnace will keep one heavy hammer busy almost continually. In others one steam hammer will serve two large forges and for some classes of work, one hammer will serve six forges.

The extent to which oil furnaces are used in blacksmith shops, allows many machines to be served by individual furnaces. The furnace and the machine are so close together that material is handled rapidly and in large quantity. By placing the machine and furnace near a door providing entrance from the storage yard material for a given class of work will be piled adjacent to the machine through which it passes and delivery from the yard is simplified. This provision is supplemented by convenient crane and track service. For instance, each bulldozer and the oil furnace adjacent to it are usually served by a swinging jib crane, so arranged as to cover the machine, furnace and an adjacent track.

Where a large amount of work of certain classes is to be done, provision for rapid movement and minimum handling reduces the cost of operation and increases the output. For instance, take the manufacture of truss rods. By placing two sets of machines of the same type in proper locations, rods may be passed from furnace to machines in such manner that both ends of the same rod are heated, upset and threaded without reversing the rod, opposite ends being worked in different furnaces and machines.

METHODS OF OPERATION.

The design, arrangement and layout of the shop are so dependent upon the class and amount of work to be turned out that it is interesting to study some of the methods introduced for rapid delivery in large bulk.

In ordering raw material for new rolling stock it is the practice of some shops to order iron cut to lengths for the various purposes required. For instance, in ordering arch bar iron, instead of calling for standard bars, the iron is ordered in pieces of required length. Such practice eliminates waste and the expense of frequent handling and allows material of a given class to be di-

rectly unloaded and piled together in locations convenient to the various machines, and advances the interest of contract workers, but it increases the difficulty of checking deliveries.

At one large railway shop where twenty-eight or thirty new box cars are built per day, in addition to the passenger car and locomotive work, such large quantities of material are delivered that a system has been developed for checking the intake and output of the shop for certain orders by determining the amount of material used in each car and recording the iron used by a count of the cars built each day. The record of all material received is then checked according to the tally of material entering into the construction of the car.

To illustrate the magnitude of the problem in checking the intake of a blacksmith shop operated on a large scale and to give some idea of the large volume of iron to be delivered for car construction work alone, attention is called to the fact that in a thirty-ton box car there are about 5,600 pounds of wrought iron and mild steel and about 23,000 pounds in a standard coach or diner.

Some of the smaller pieces made in the blacksmith shop, such as nuts, bolts, etc., require so much handling during the process of manufacture, that unless transferred in bulk the cost of handling equals or exceeds the cost of forging. The necessity of cheap and rapid movement has developed methods whereby the pieces are not allowed to touch the floor. This includes the use of specially designed boxes, in some cases mounted on wheels, so that in passing through the several machines material passes from one box or wagon to another and all deliveries are made in bulk.

List of Equipment in Representative Railway Blacksmith Shops

A., T. & S. F. RY.—TOPEKA.

Machine.	Size.	Maker.
4 Steam generating furnaces	90 h. p.	A., T. & S. F. Ry.
1 large furnace	No. 3	A., T. & S. F. Ry.
3 Spring furnaces		A., T. & S. F. Ry.
2 Band furnaces		A. T. & S. F. Ry.
6 Miscellaneous furnaces	Small	A., T. & S. F. Ry.
2 Feed water pumps	No. 8	Knowles
2 Double frame steam hammers	5,000 lbs.	Chambersburg Eng. Co.
1 Double frame steam hammer	4,000 lbs.	Niles, Bement, Pond Co.
1 Single frame steam hammer	2,500 lbs.	Niles, Bement, Pond Co.
1 Single frame steam hammer	1,500 lbs.	Niles, Bement, Pond Co.
1 Single frame steam hammer	1,100 lbs.	Niles, Bement, Pond Co.
1 Single frame steam hammer	1,100 lbs.	Morgan
2 Single frame steam hammers	250 lbs.	Morgan
1 Single frame steam hammer	150 lbs.	Morgan
2 Single frame steam hammers	250 lbs.	Bement
1 Single frame steam hammer	850 lbs.	Bement
1 Single frame pneu. hammer		A., T. & S. F. Ry.
1 Forging machine	4 ins.	Ajax Manufacturing Co.
1 Bulldozer	Large	Williams, White & Co.
2 Bulldozers	Small	A., T. & S. F. Ry.
3 Bolt headers	1½ in.	Oliver
1 Bolt header	2½ ins.	Ajax Manufacturing Co.
1 Bolt header	¾ in.	Burdick
1 Bolt header	2 ins.	National
1 Motor-driven punch and shear	2½ ins.	Williams, White & Co.
1 Steam punch and shear	3 ins.	Hercules Iron Works
1 Washer punch	13-in. throat	
1 Punch and shear	¾ in.	Colton
1 Spring punch and shear		John Evans' Sons
1 Taper rolls		John Evans' Sons
1 Eye bolt machine		Williams, White & Co.
1 Brake lever rolls		Ajax Manufacturing Co.
1 Arch bar drill	6 spindle	Niles-Bement-Pond Co.
1 Heavy grinder (double)	24 ins.	A., T. & S. F. Ry.
1 Emery grinder	24 ins.	A., T. & S. F. Ry.
1 Band press		Tinnis, Oleson & Co.
1 Nibber and trimmer		John Evans' Sons
1 Spring tester		Riehle
1 Case hardening furnace		A., T. & S. F. Ry.
1 Annealing furnace		A., T. & S. F. Ry.
1 Pressure blower	No. 10	B. F. Sturtevant & Co.
1 Pressure blower	No. 9	B. F. Sturtevant & Co.
1 Pressure blower	No. 8	B. F. Sturtevant & Co.
40 Smith fires		

B. R. & P. RY.—DU BOIS.

Machine.	Size.	Maker.
1 Double frame steam hammer	3,000 lbs.	Niles-Bement-Pond Co.
1 Single frame steam hammer	800 lbs.	Niles-Bement-Pond Co.
1 Dead stroke hammer	50 lbs.	Scranton & Co.
1 Comb. power cutting-off saw	No. 2	Newton Machine Tool Wks.
1 Flue cleaner		Otto
1 Flue-welding machine		Hartz
1 Flue-welding furnace		Railway Materials Co.
1 Pair flanging clamps, air operated	12 ft.	
1 Pair flanging clamps, hand operated	9 ft.	
1 Spring forming machine		
2 Tube rolling and cutting out machines		Acme Machinery Co.
1 Band saw	48 ins.	Clement
1 Heavy pattern single spindle radial vertical right-hand boring machine	No. 6B	Greenlee Bros. & Co.

CANADIAN PACIFIC RAILWAY—ANGUS.

Machine.	Size.	Maker.	Motor H.P.
Hammer	2,000 lbs.	Niles-Bement-Pond Co.	
Hammer	6,000 lbs.	Niles-Bement-Pond Co.	
Hammer	3,500 lbs.	Davy Bros.	
Hammer	1,200 lbs.	Davy Bros.	
Hammer	3,000 lbs.	Niles-Bement-Pond Co.	
Hammer	1,200 lbs.	Davy Bros.	
Hammer	1,500 lbs.	Niles-Bement-Pond Co.	
Upsetting machine	5 ins.	Ajax Manufacturing Co.	15
Hammer	600 lbs.	Davy Bros.	
Hammer	400 lbs.	J. Bertram & Sons Co.	
Hammer	600 lbs.	Davy Bros.	
Hammer	250 lbs.	Niles-Bement-Pond Co.	
Hammer	250 lbs.	Niles-Bement-Pond Co.	10
Punch and shears		J. Bertram & Sons Co.	10
Beaudry hammer		Beaudry Manufacturing Co.	3
Flat iron saw		C. P. R.	5
Spring rolls		Craven Bros.	5
Spring taper machine		Craven Bros.	5
Hammer	200 lbs.	C. C. Bradley & Son	5
Hammer	100 lbs.	C. C. Bradley & Son	3
Hammer	100 lbs.	C. C. Bradley & Son	3
Hammer	100 lbs.	C. C. Bradley & Son	3
Eye bolt machine		Williams, White & Co	3
Bolt header	1½ in.	National Machine Co	5
Eye bolt machine		Williams, White & Co	3
Forging machine	2 ins.	Ajax Manufacturing Co	10
Rivet Machine	1½ in.	Ajax Manufacturing Co	5
Forging machine		Ajax Manufacturing Co	5
Single shears		J. Bertram & Co	3
Upsetting machine	2 ins.	Ajax Manufacturing Co	10
Bolt cutter	2 ins.	J. Bertram & Co	3
Upsetting machine	3 ins.	Ajax Manufacturing Co	10
Bolt cutter	2 ins.	J. Bertram & Co	3
Nut burring	2 ins.	Ajax Manufacturing Co	3
Forging machine	3 ins.	Ajax Manufacturing Co	10
Nut burring machine	1½ in.	Ajax Manufacturing Co	3
Nut machine	1½ in.	National Machine Co	10
Nut burring machine		Ajax Manufacturing Co	3
Nut machine	⅝ in.	National Machine Co	5
Bolt header	1½ in.	National Machine Co	5
Round iron shears		J. Bertram & Co	3
Round iron shears		J. Bertram & Co	3
Bolt header	1½ in.	National Machine Co	5
Round iron shears		J. Bertram & Co	3
Bolt header	2 ins.	National Machine Co	5
Bulldozer	No. 6	Williams, White & Co	15
Bulldozer	No. 5	Williams, White & Co	10
Bulldozer	No. 6	Williams, White & Co	15
Bulldozer	No. 4	Williams, White & Co	10
Bulldozer	No. 5	Williams, White & Co	10
Bulldozer	No. 4	Williams, White & Co	10
Punch and shears		J. Bertram & Co	10
Hammer	2,000 lbs.	J. Bertram & Co	
Hammer	1,200 lbs.	J. Bertram & Co	
Hammer	2,000 lbs.	Niles-Bement-Pond Co.	
Punch and shears		J. Bertram & Co	15
Punch and shears		J. Bertram & Co	10
Bulldozer	No. 4	Williams, White & Co	10
Punch and shears		J. Bertram & Co	15
Hammer	600 lbs.	Davy Bros.	
Bolt header	1½ in.	National Machine Co	5
Fire brick crusher		C. P. R.	
Hyd. Buckles press		C. P. R.	
Hammer	4,400 lbs.	Niles-Bement-Pond Co.	
Hammer	2,000 lbs.	Niles-Bement-Pond Co.	
Upsetting machine	2 ins.	Ajax Manufacturing Co.	
Eyebolt machine		Ajax Manufacturing Co.	
Beaudry hammer	350 lbs.	Beaudry Manufacturing Co.	5
Hammer	200 lbs.		
Brake key rolls			

LIST OF FURNACES AT ANGUS, C. P. RY.

Extra large forging furnace, 6 ft. 6 ins. deep x 18 ft. long, with two doors, for 6,000-lb. hammer.

Large forging furnace, 5 ft. deep x 7 ft. long, with two doors for 3,500-lb. hammer.
Case-hardening furnace, 5 ft. x 7 ft., standard design, clear opening in front.
Large forging furnace, 5 ft. deep x 7 ft. long, with two doors, for 3,000-lb. hammer.
Large forging furnace, 4 ft. 2 ins. deep x 36 ins. long, with one door for 1,500-lb. hammer.
Small forging furnace for upsetting machine.
No. 2 forging furnace for Beaudry hammer.
No. 2 forging furnace for Beaudry hammer.
Small forging furnace for brake key rolls.
Spring bending furnace, 28 ins. wide x 31 ins. deep, with one door, for buckle press.
Spring tempering furnace, 15 ft. 6 ins. long x 5 ft. wide, furnished with eight doors, arranged four on each side, for four fitters and four helpers.
Spring tempering and nibbing furnace, for spring rolls.
No. 2 forging furnace for Bradley hammer.
No. 2 forging furnace for Bradley hammer.
No. 2 forging furnace for Bradley hammer.
No. 2 forging furnace for Bradley hammer.
Small forging furnace, bricked up, for bolt header.
Small forging furnace, bricked up, for eye-bolt machine.
Small forging furnace, bricked up, for bolt header.
Small forging furnace, bricked up, for eye-bolt machine.
Forging machine, 5 ft. deep x 28 ins. wide, with one door for continuous rivet-making machine.
Small forging furnace, bricked up, for forging machine.
No. 2 forging furnace for 2-in. upsetting machines.
No. 2 forging furnace for 3-in. upsetting machine.
Forging furnace, 31 ins. deep x 28 ins. wide, with one door for nut machine.
Forging furnace, 5 ft. deep, 28 ins. wide with one door, for nut machine.
Forging furnace, 5 ft. deep, 28 ins. wide with one door, for nut machine.
Small forging furnace, bricked up, for bolt header.
Small forging furnace, bricked up, for bolt header.
Small forging furnace, bricked up, for bolt header.
Double bulldozer furnace, with two furnaces for heating material, each 8 ft. 11 ins. long x 36 ins. wide, with one door for 15 h. p. bulldozer.
Double bulldozer furnace, with two furnaces for heating material, each 8 ft. 11 ins. long x 36 ins. wide, with one door for 20 h. p. bulldozer.
Double bulldozer furnace, with two furnaces for heating material, each 8 ft. 11 ins. long x 36 ins. wide, with one door for 15 h. p. bulldozer.
Single bulldozer furnace, 8 ft. 11 ins. long x 36 ins. wide, with one door for 15 h. p. bulldozer.
Single bulldozer furnace, 8 ft. 11 ins. long x 36 ins. wide, with one door for 10 h. p. bulldozer.
Large forging furnace, 4 ft. 2 ins. deep x 36 ins. long, with one door for 2,000-lb. hammer.
Large forging furnace, 5 ft. deep x 7 ft. long, with two doors for 2,000-lb. hammer.
Single bulldozer furnace, 8 ft. 11 ins. long x 36 ins. wide, with one door for 10 h. p. bulldozer.
Furnaces in this list provided by Railway Materials Co.

C., R. I. & P. RY.—SILVIS.

	Machine.	Size.	Maker.
	Hydraulic bar shears	2-ft. round	Niles-Bement, Pond Co.
	Double stay-bolt cutter	1½-ins	Acme Machinery Co.
	Bolt pointer		Acme Machinery Co.
	Forging machine	No. 3	Ajax Manufacturing Co.
	Long-stroke hammer	1,600 lbs.	Chambersburg Engr. Co.
	Single-stand hammer	1,500 lbs.	Chambersburg Engr. Co.
	Single-stand hammer	1,500 lbs.	Chambersburg Engr. Co.
	Hydraulic bar shears	1¼ by 12	Niles, Bement, Pond Co.
	Hydraulic punch and shear	20-ins	Niles, Bement, Pond Co.
	Bolt header	1⅛ ins	Ajax Manufacturing Co.
	Cold saw		Hegley-Cambria
	Double-stand steam hammer	5,000	
	Single-stand steam hammer	1,100	
	Single-stand steam hammer	1,000	
2	Double staybolt cutters	1⅛ in.	
	Hammer riveter, pneumatic	84 in. reach	John F. Allen
	Portable mud ring riveter, pneumatic		Pedrick & Ayer
	Portable riveter		Pedrick & Ayer
	Arch bar drill	Six spindle	
	Cushioned hammers	200 lbs.	C. C. Bradley & Son
2	Bolt headers	1-in.	Ajax Manufacturing Co.

L. S. & M. S. RY.—COLLINWOOD.

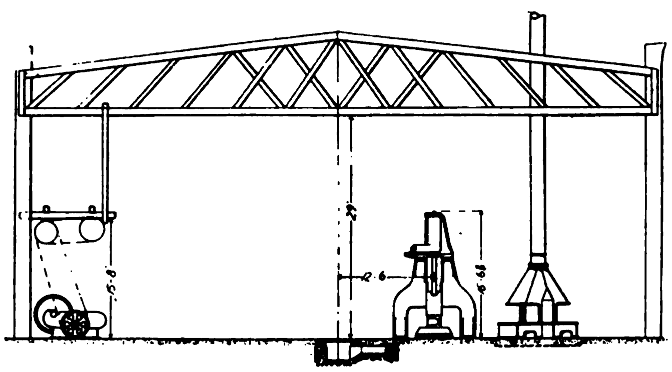
Machine.	Size.	Maker.	Motor H. P.
Volume Blower	No. 11	Buffalo Forge Co	50
Steel Plate Exhauster	110 ins.	Buffalo Forge Co	
Bolt Header	1½ ins.	Acme Machinery Co.	
Bolt Header	1½ ins.	Acme Machinery Co.	20
Forging Machine	2½ ins.	Ajax Machinery Co	
Bolt Header	1½ ins.	Acme Machinery Co.	
Triple Head Bolt Cutter	2 ins.	Acme Machinery Co.	
Triple Head Bolt Cutter	1½ ins.	Acme Machinery Co.	
Triple Head Bolt Cutter	1½ ins.	Acme Machinery Co.	15
Double Head Bolt Cutter	2½ ins.	Acme Machinery Co.	
Nut Tapper	8-spindle	Acme Machinery Co.	
Nut Tapper	8-spindle	Acme Machinery Co.	
Large Tapering Rolls		John Evans' Sons	
Combined Nipper and Trimmer Machine		John Evans' Sons	15
Combined Punch and Shear		John Evans' Sons	
Compact Hammer	200 lbs.	C. C. Bradley & Son	
Compact Hammer	200 lbs.	C. C. Bradley & Son	
Compact Hammer	200 lbs.	C. C. Bradley & Son	20
Compact Hammer	200 lbs.	C. C. Bradley & Son	
Compact Hammer	50 lbs.	C. C. Bradley & Son	

L. & N. R. R.—SOUTH LOUISVILLE.

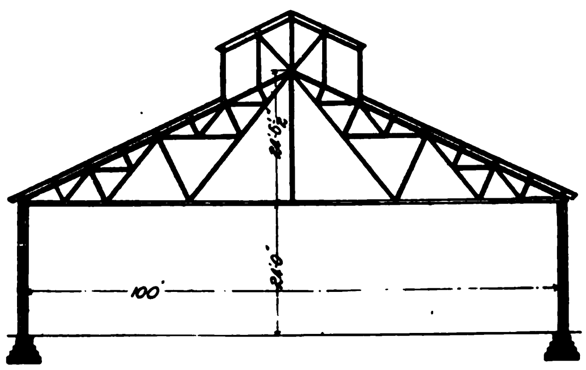
	Machine.	Size.	Maker.
1	Steam Hammer	6,000 lbs.	Chambersburg Engr. Co.
1	Steam Hammer	4,500 lbs.	Niles-Bement-Pond Co.
1	Steam Hammer	3,500 lbs.	Chambersburg Engr. Co.
1	Steam Hammer	2,500 lbs.	Niles-Bement-Pond Co.
2	Steam Hammers	1,500 lbs.	Niles-Bement-Pond Co.
1	Steam Hammer	1,000 lbs.	William Sellers & Co.
4	Hammers	200 lbs.	C. C. Bradley & Son
1	No. 9 Forging Machine		Ajax Manufacturing Co.
1	Forging Machine	4 ins.	Ajax Manufacturing Co.
1	Forging Machine	2 ins.	Ajax Manufacturing Co.
1	Forging Machine	1½ ins.	Ajax Manufacturing Co.
2	Forging Machines	1 in.	Ajax Manufacturing Co.
2	Forging Machines	1 in.	Oliver
3	Compressed Air Bulldozers	18 ins.	L. & N. R. R.
1	Compressed Air Bulldozer	10 ins.	L. & N. R. R.
1	Eye Bolt Header		Williams, White & Co.
1	Combination Punch and Shear	Punch reach 27 ins. Shear, 28 ins.	Niles-Bement-Pond Co.
1	No. 5 Punch	15 ins. reach	Hilles & Jones
1	Shear and Trimmer	24 ins. reach	William Sellers & Co.
2	Round Iron Shears		Niles-Bement-Pond Co.
3	Drill Presses	34 ins.	Harrington & Son
1	Drill Press	36 ins.	Niles-Bement-Pond Co.
1	Drill Press	30 ins.	Putnam Machine Co.
1	Drill Press	30 ins.	David W. Pond Co.
1	Drill Press	36 ins.	Aurora Tool Works
1	Drill	4 spindle	W. F. & J. Barnes Co.
8	Threading Machines	1½ ins., 2 spindles	Acme Mach. Co.
1	Threading Machine	2 ins., 2 spindles	Acme Mach. Co.
1	Threading Machine	1½ ins., 4 spindles	Acme Mach. Co.
1	Threading Machine	2 ins., 3 spindles	Acme Mach. Co.
1	Nut Tapper	2 ins., 6 spindles	Acme Mach. Co.
1	Nut Tapper	1½ ins., 6 spindles	Acme Mach. Co.
1	Nut Tapper	¾ in., 2 spindles	
1	Nut Tapper	1 in., 6 spindles	Acme Mach. Co.
1	Nut Tapper	2 ins., 4 spindles	
1	Nut Tapper	7-8 in., 6 spindles	Niles-Bement-Pond Co.
4	No. 1 Heating Furnaces		Railway Materials Co.
9	No. 2 Heating Furnaces		Railway Materials Co.
5	Box Furnaces		Railway Materials Co.
	Case Hardening Furnace		Railway Materials Co.
	Axle Furnace		Railway Materials Co.
	Emery Grinder		L. & N. R. R.

PENNSYLVANIA RAILROAD—OLEAN.

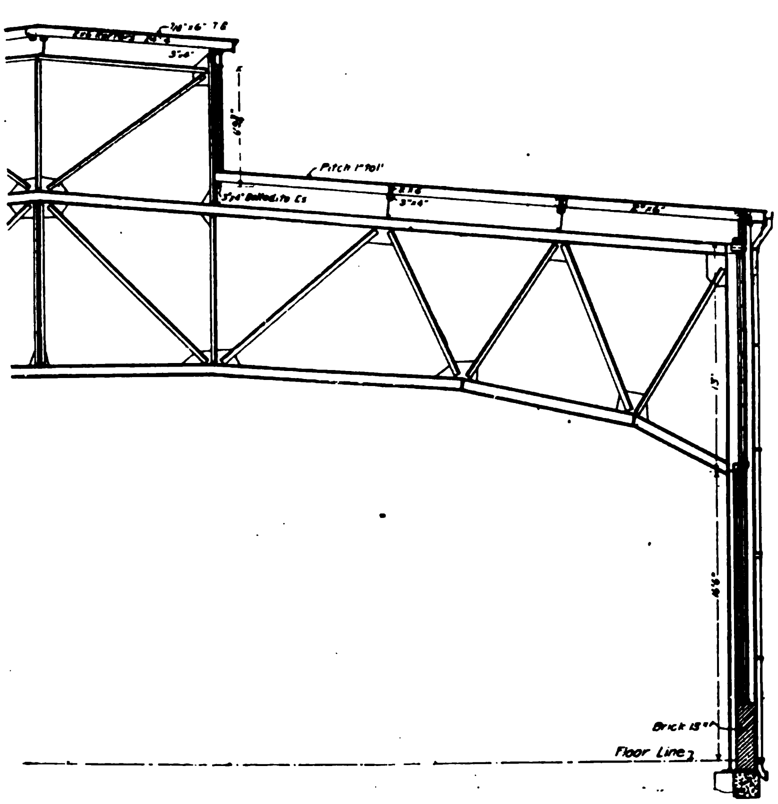
	Machine.	Size.	Maker.	Motor H. P.
	Tempering Furnace			
	Single Frame Steam Hammer	250 lbs.	Chambersburg	
2	Single Frame Steam Hammers	2,000 lbs.	Chambersburg	
	Double Frame Steam Hammer	4,000 lbs.	Chambersburg	
	Frame Fire			
	Scrap Furnace			
	Case Hardening Furnace			
	Flue Tester			
	Flue Heating Furnace		Railway Materials Co.	
	Flue Cutting Off Machine	(Indiv. Drive, 1-H. P. motor).		
	Spring Heating Furnace			
	Spring Annealing Furnace			
	Spring Band Heating Furnace			
	Hydraulic Spring Unbanding Press			
	Hydraulic Spring Banding Press			
	Flue Welding Furnace		Railway Materials Co.	
	Flue Welding Machine			
	Flue Cutting Off Machine			
	Spring Cambering Machine			20
	Rolls, Shears and Nibbing Machine			
	Punch and Shears			
	Heating Furnace			
	Spring Testing Machine	50,000 lbs. capacity	Riehle	
	Shears		Hilles & Jones	
	Upsetting and Forging Machine	2½ ins.	Acme	
	Upsetting Machine	1½ ins.	Ajax	
	Triple Head Bolt Cutter	2 ins.	Landis	25
	Bolt Cutter	2 spin. 3 in.	Acme	
	Bolt Cutter	2 spin. 2 in.	Acme	
	Bolt Cutter	2 spin. 1½ in.	Acme	



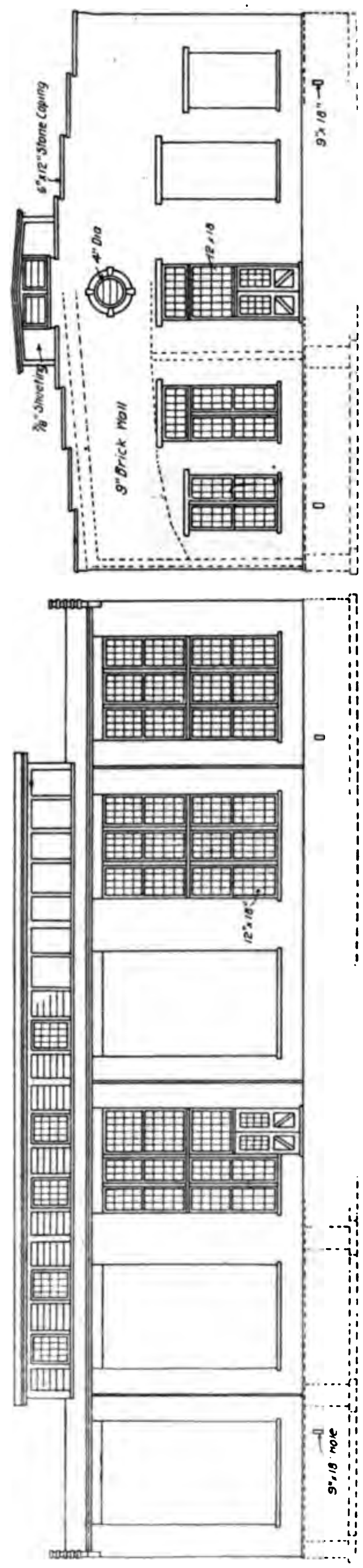
CROSS SECTION OF BLACKSMITH SHOP AT OLEAN, P. R. R



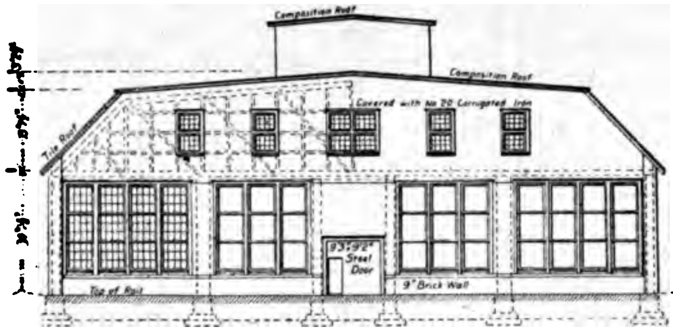
CROSS SECTION OF BLACKSMITH SHOP AT DANVILLE. ILL., C. & E. I. R. R.



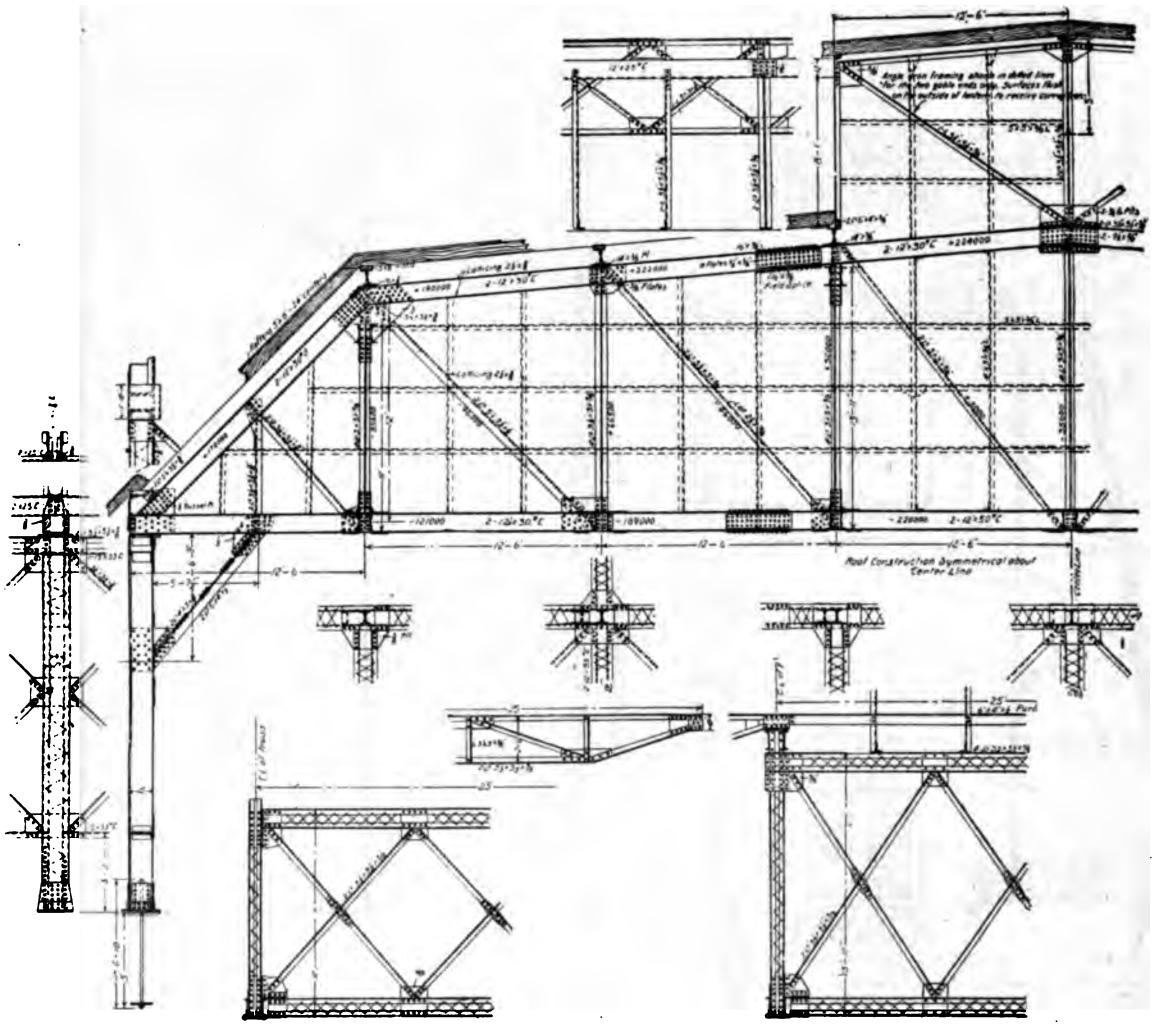
CROSS SECTION OF BLACKSMITH SHOP AT LA JUNTA, COL., A. T. & S. F. RY.



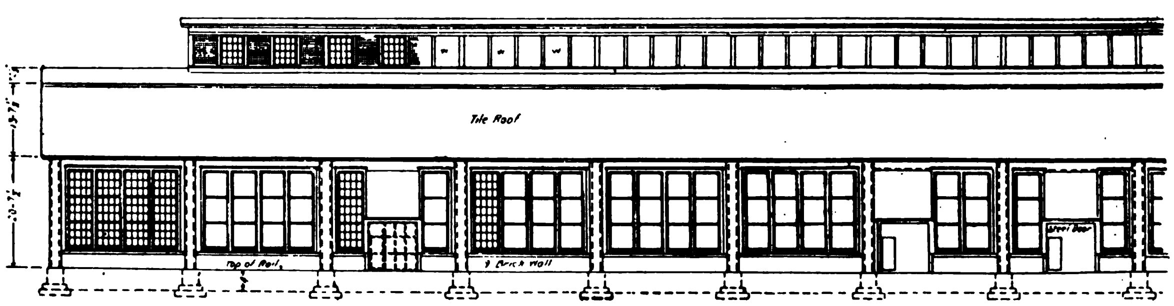
ELEVATION OF BLACKSMITH SHOP AT LA JUNTA, COL., A., T. & S. F. RY.



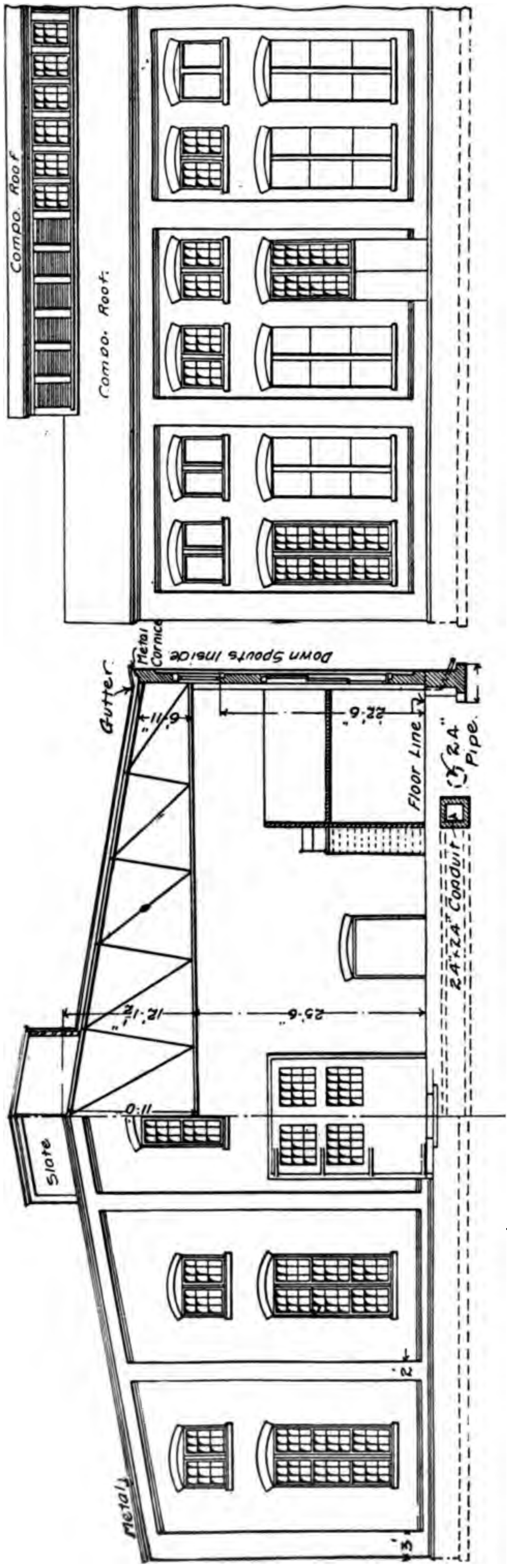
END ELEVATION OF BLACKSMITH SHOP AT TOPEKA, A. T. & S. F. RY.



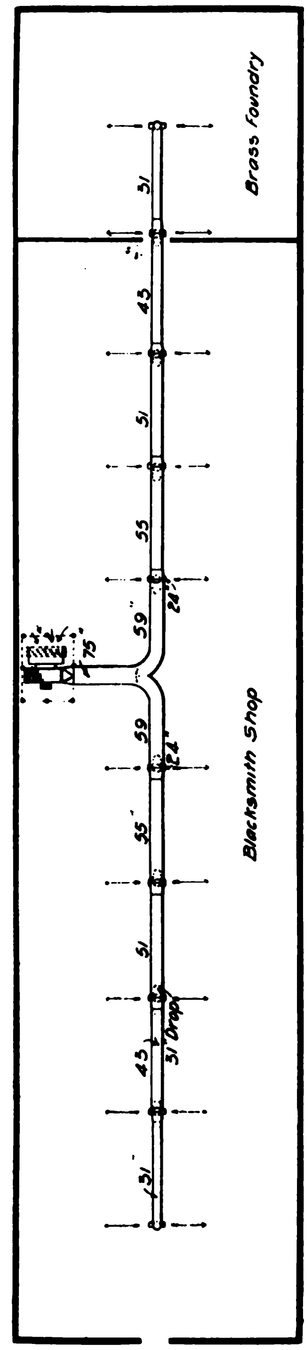
PARTIAL SECTION AND DETAILS OF CONSTRUCTION OF BLACKSMITH SHOP AT TOPEKA, A., T. & S. F. RY.



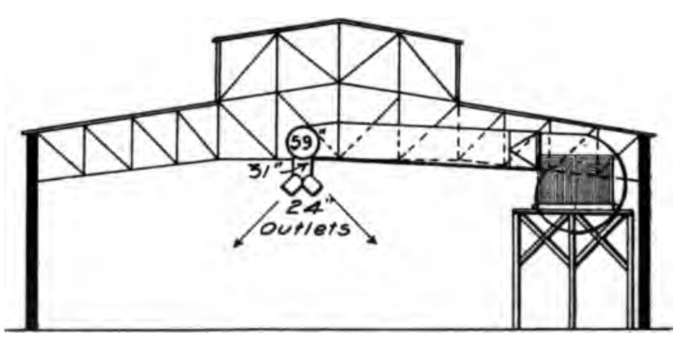
HALF SIDE ELEVATION OF BLACKSMITH SHOP AT TOPEKA, A., T. & S. F. RY.



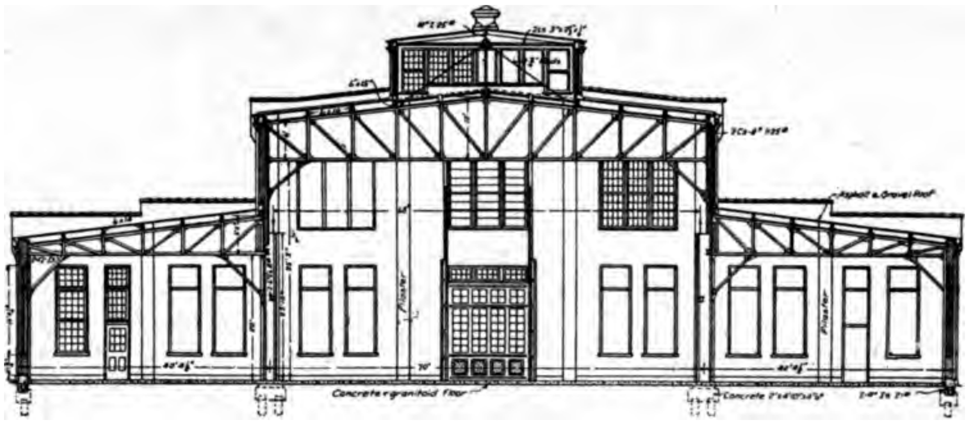
PARTIAL ELEVATION AND SECTION OF BLACKSMITH SHOP AT SILVIS, C., R. I. & P. RY.



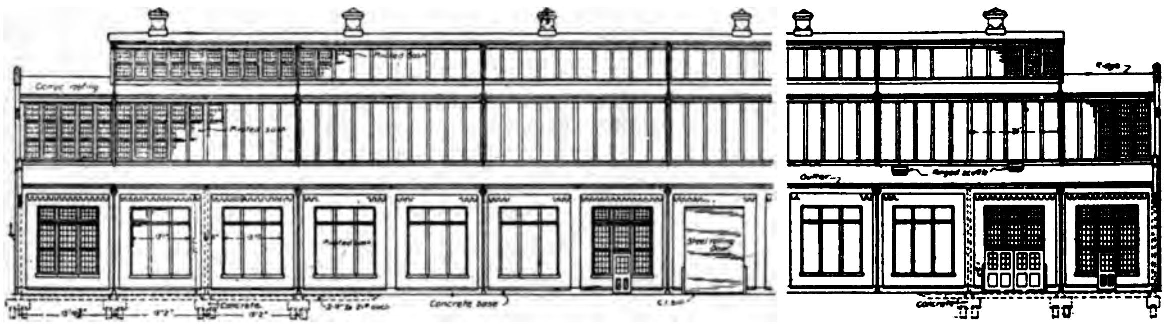
PLAN OF HEATING SYSTEM IN BLACKSMITH SHOP AT SILVIS, C., R. I. & P. RY.



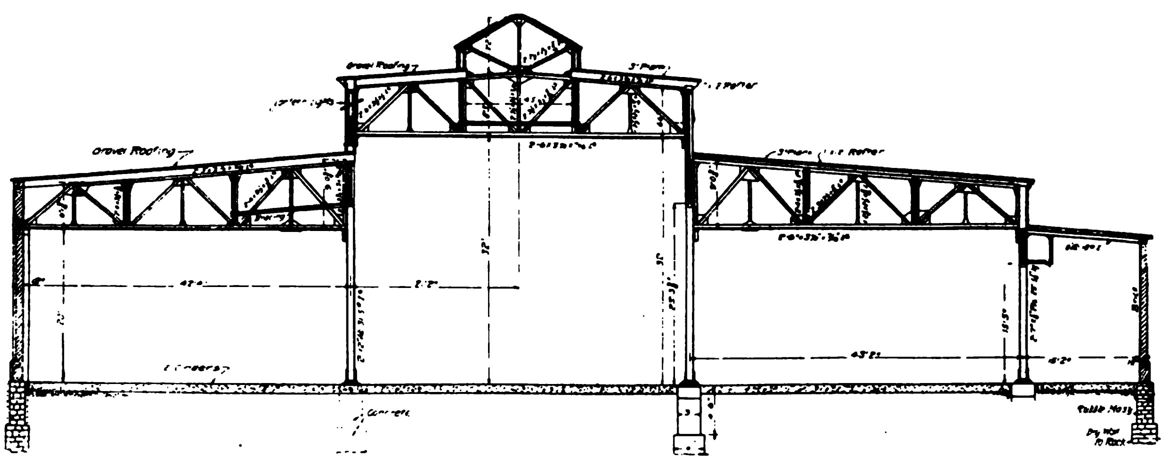
CROSS SECTION OF BLACKSMITH SHOP AT SILVIS, C., R. I. & P. RY.—SHOWING HEATER PIPES.



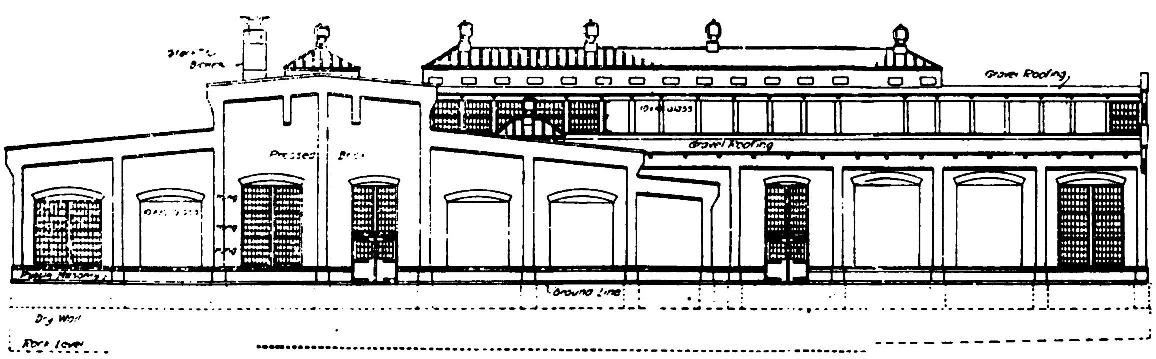
CROSS SECTION OF BLACKSMITH SHOP AT SOUTH LOUISVILLE, L. & N. R. R.



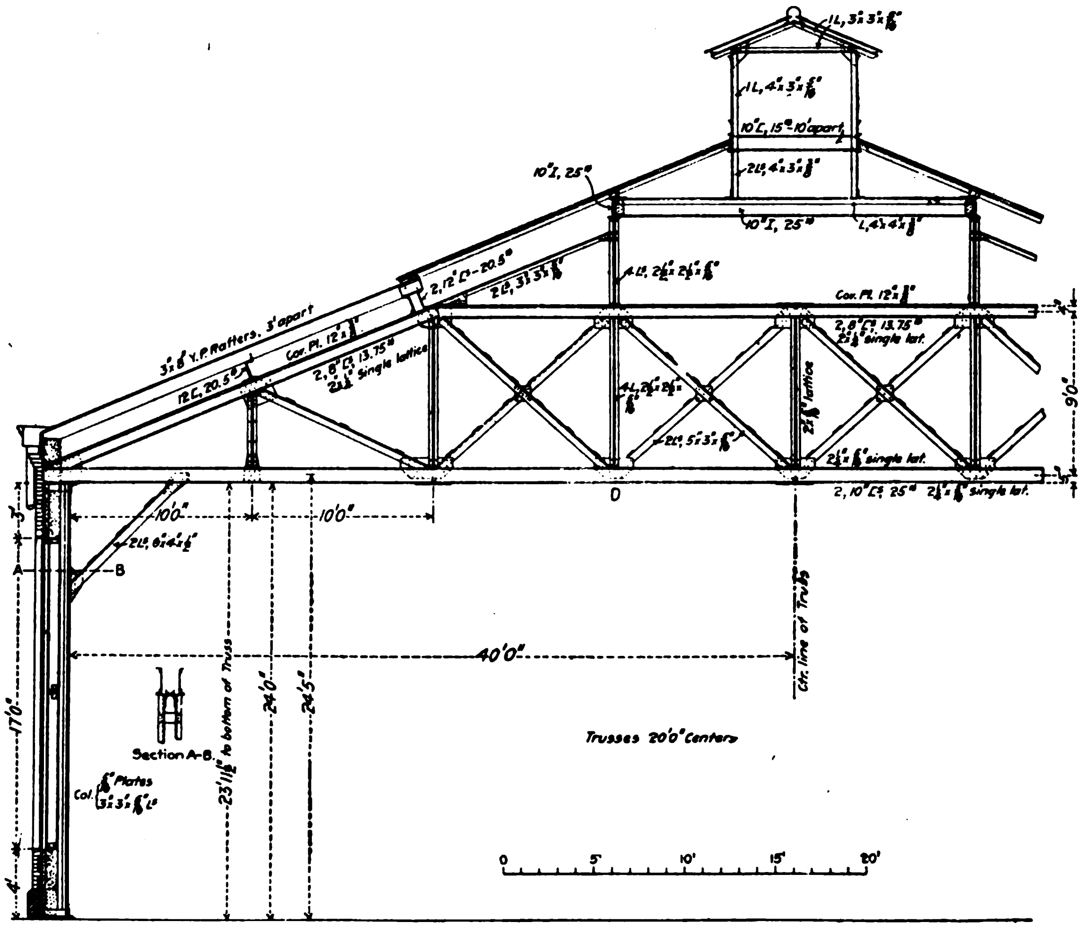
SIDE ELEVATION OF BLACKSMITH SHOP AT SOUTH LOUISVILLE, L. & N. R. R.



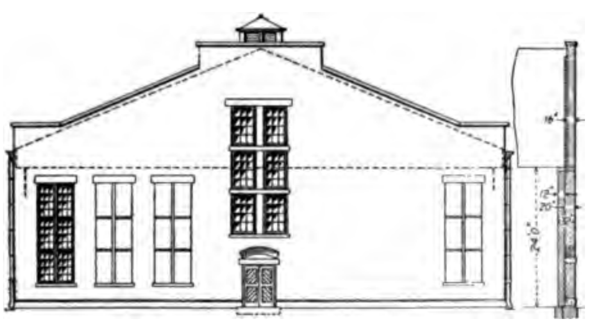
CROSS SECTION OF BLACKSMITH SHOP AT ANGUS, C. P. RY.



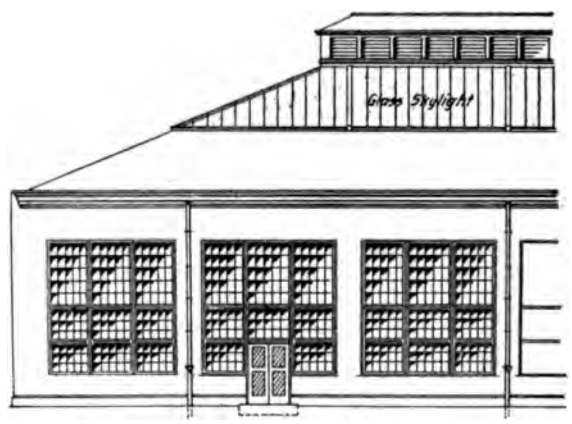
ELEVATION OF BLACKSMITH SHOP AT ANGUS, C. P. RY.



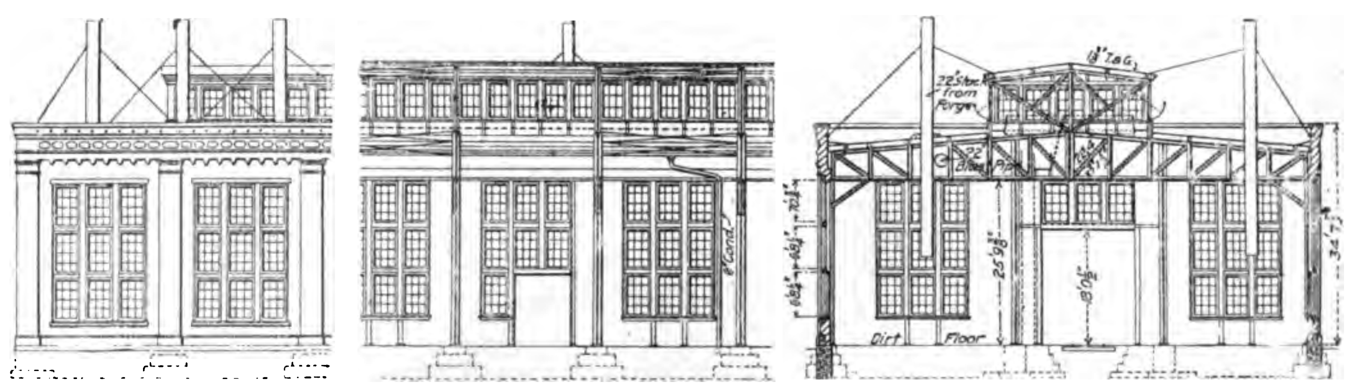
CROSS SECTION OF BLACKSMITH SHOP AT COLLINWOOD, L. S. & M. S. RY.



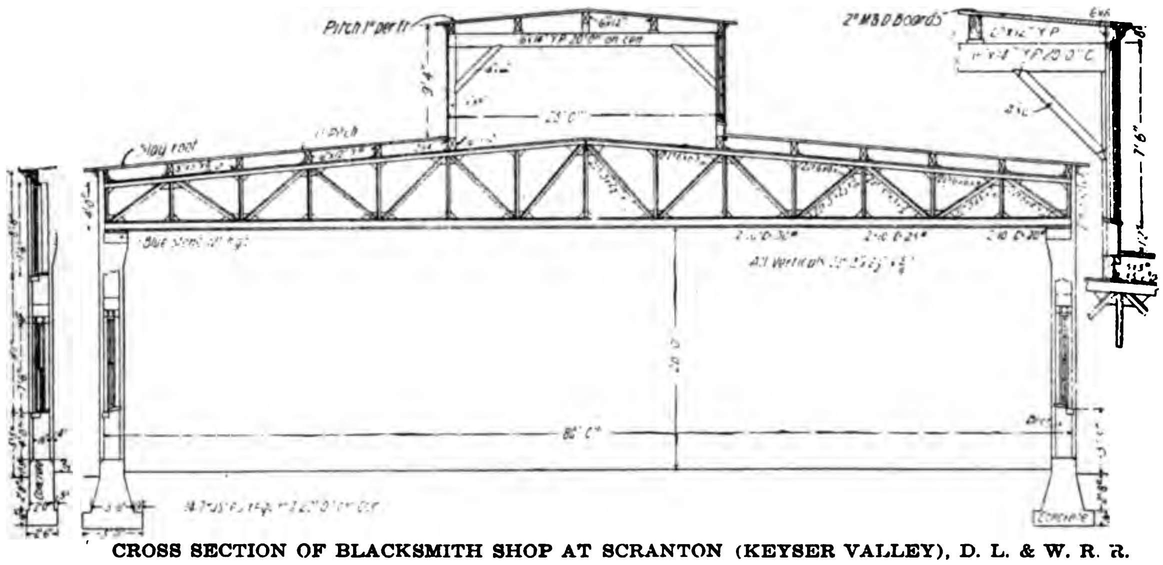
END ELEVATION OF BLACKSMITH SHOP AT COLLINWOOD, L. S. & M. S. RY.



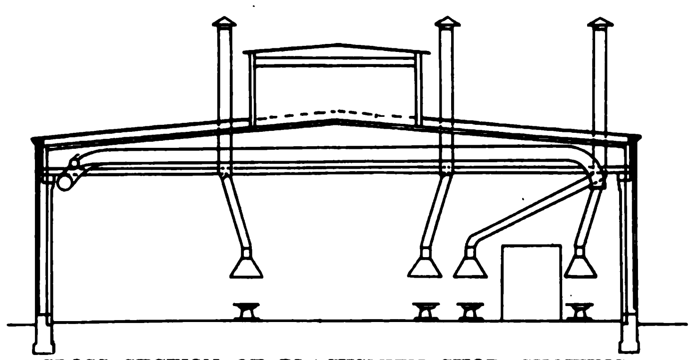
SIDE ELEVATION OF BLACKSMITH SHOP AT COLLINWOOD, L. S. & M. S. RY.



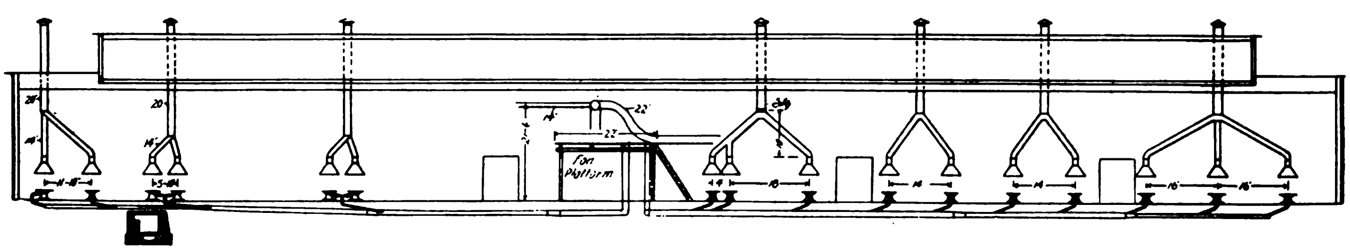
PARTIAL ELEVATIONS AND SECTIONS OF BLACKSMITH SHOP AT M'KEES ROCKS, P. & L. E. R. R.



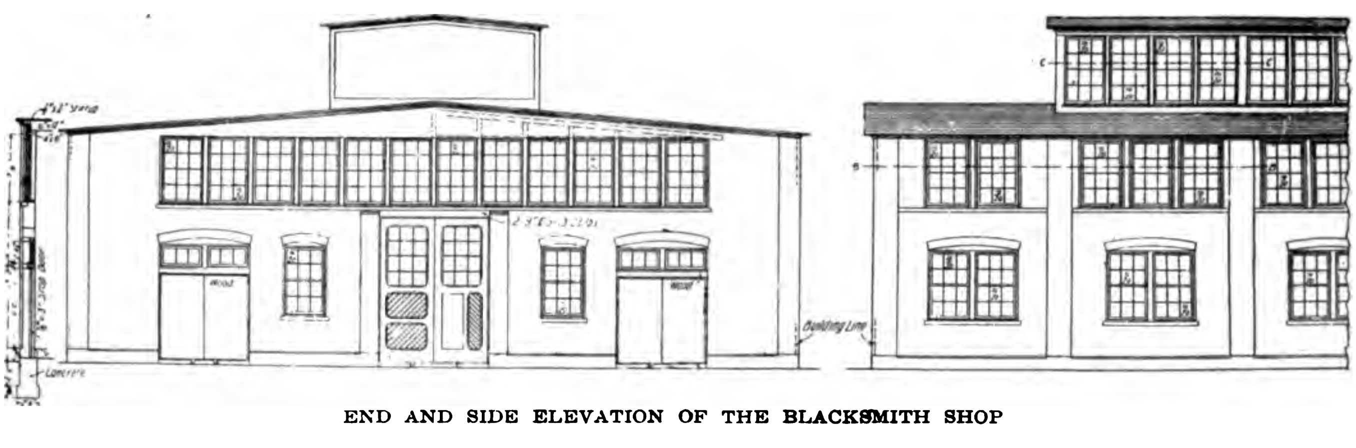
CROSS SECTION OF BLACKSMITH SHOP AT SCRANTON (KEYSER VALLEY), D. L. & W. R. R.



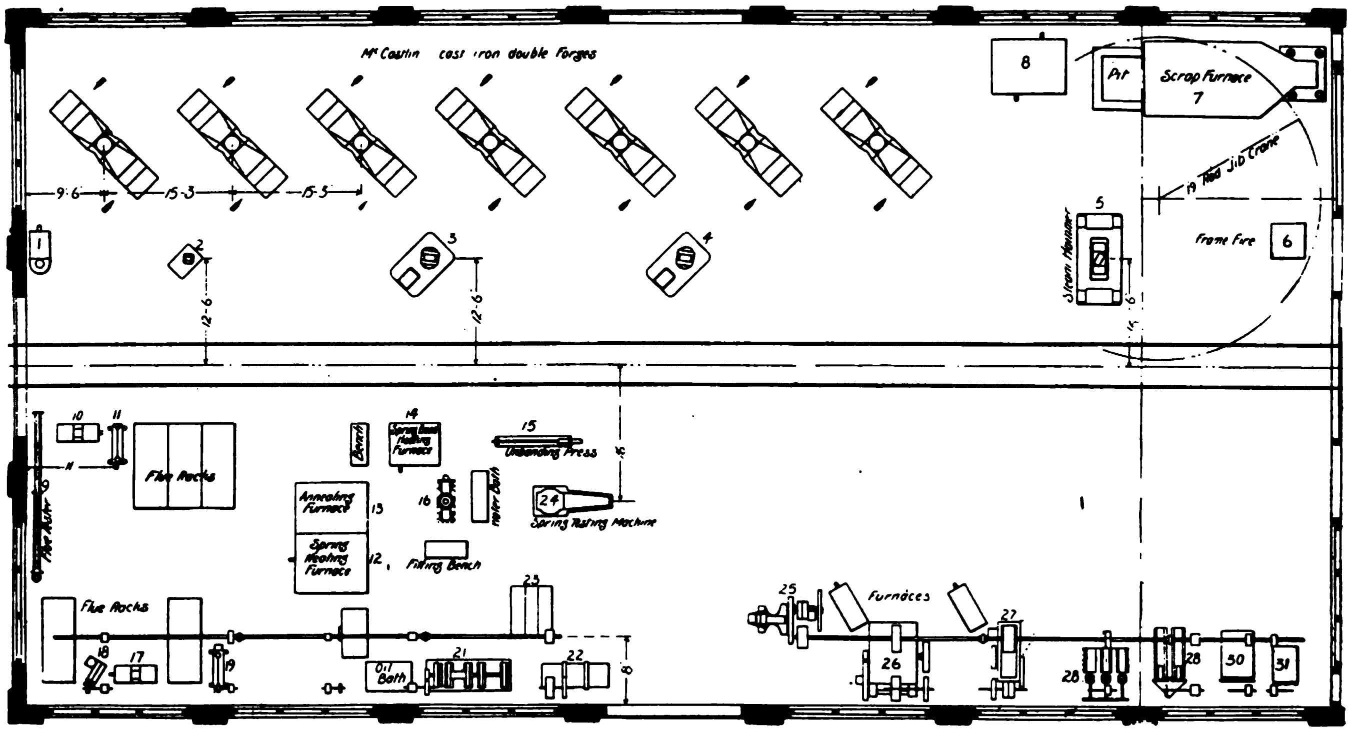
CROSS SECTION OF BLACKSMITH SHOP, SHOWING ARRANGEMENT OF EXHAUST PIPES AND HOODS AT SCRANTON, D., L. & W. R. R.



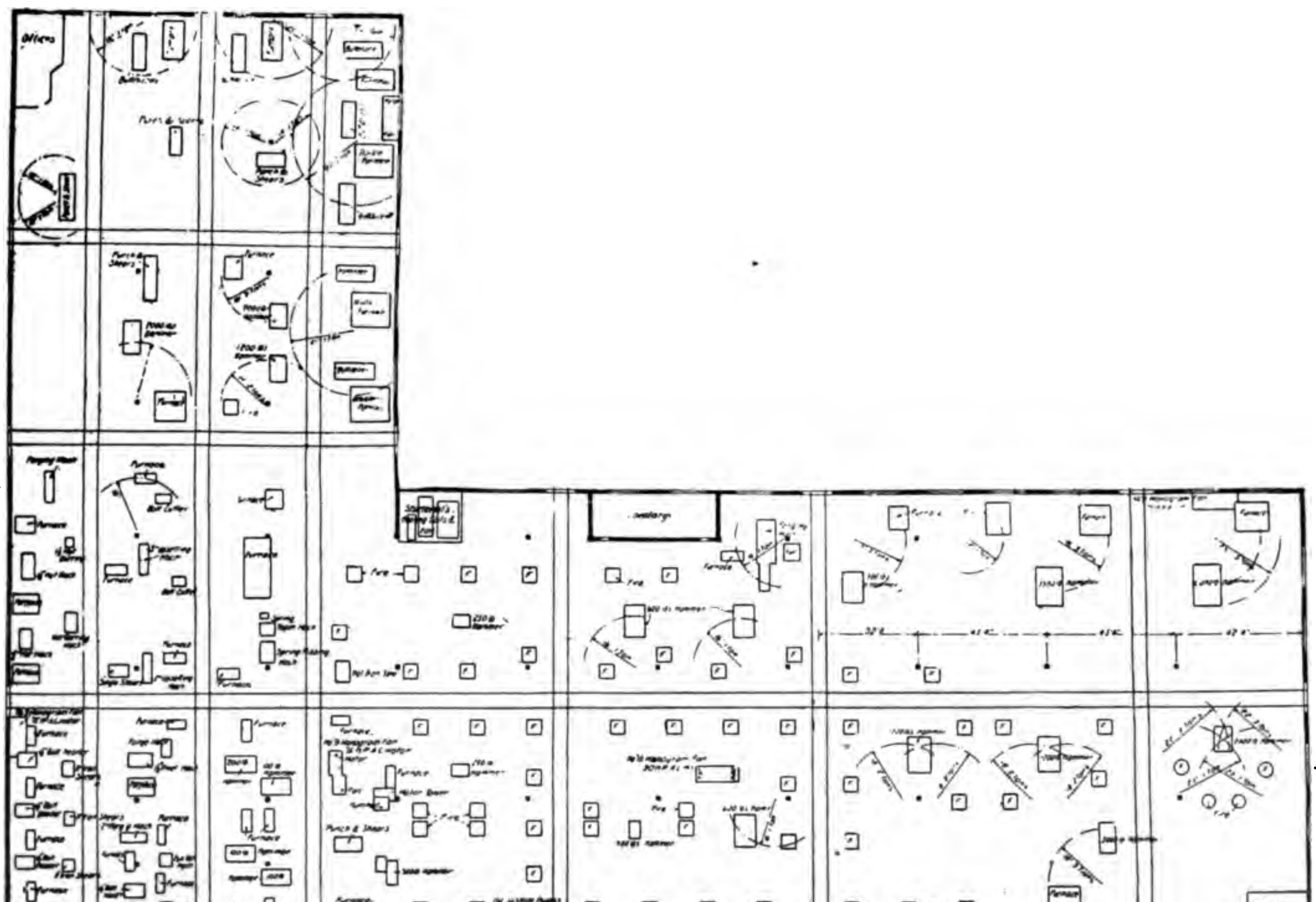
LONGITUDINAL SECTION OF BLACKSMITH SHOP, SHOWING ARRANGEMENT OF EXHAUST PIPES AND HOODS AT SCRANTON, D., L. & W. R. R.



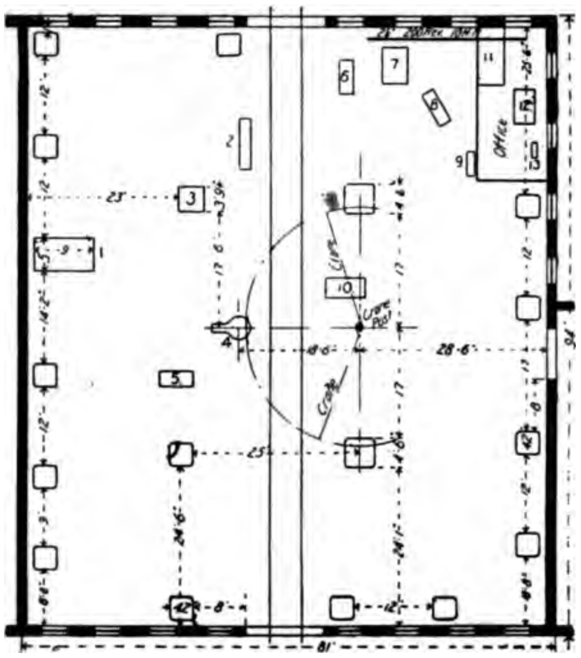
END AND SIDE ELEVATION OF THE BLACKSMITH SHOP



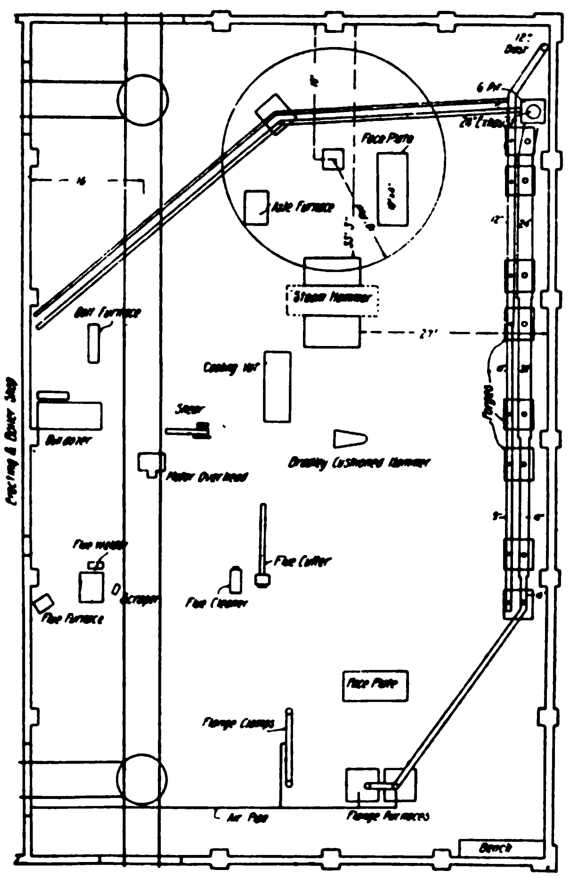
PLAN OF BLACKSMITH SHOP, SHOWING ARRANGEMENT OF EQUIPMENT AT OLEAN, N. Y., P. R. R.



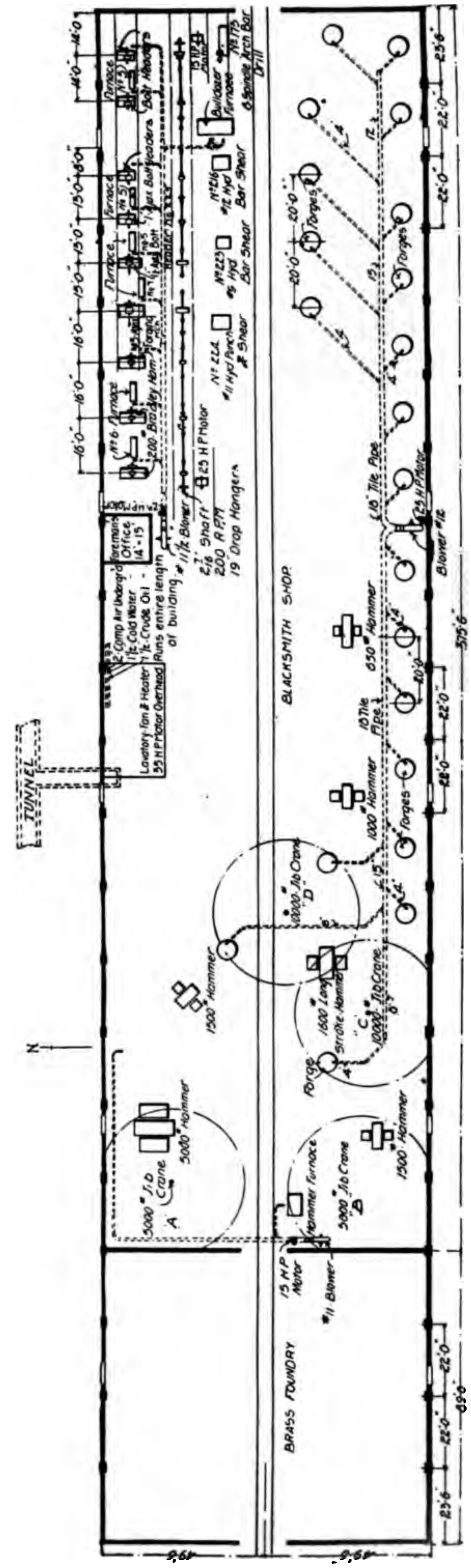
PLAN OF BLACKSMITH SHOP, SHOWING ARRANGEMENT OF EQUIPMENT AT ANGUS, C. P. RY.



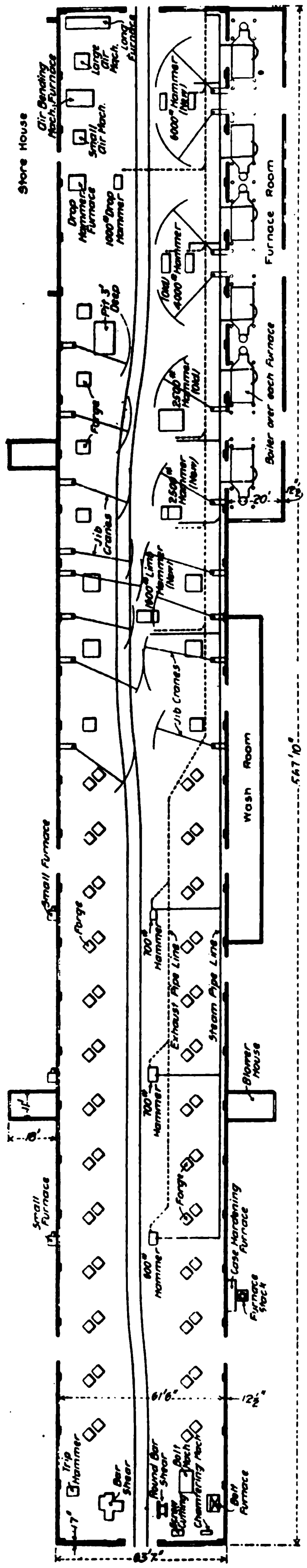
PLAN OF BLACKSMITH SHOP AT OELWEIN, C. G. W. RY.



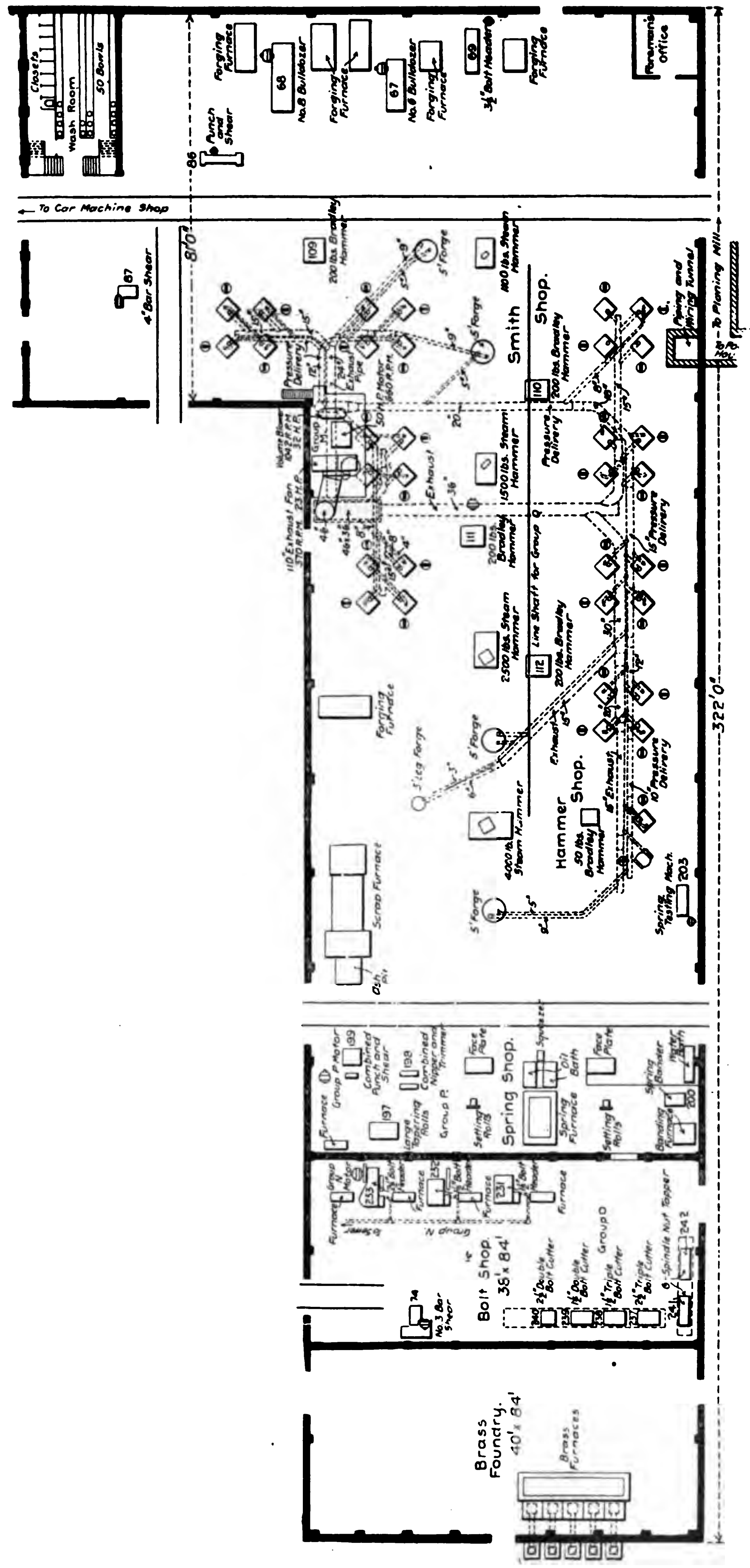
PLAN OF BLACKSMITH SHOP, SHOWING LAYOUT OF EQUIPMENT AT EAST ST. LOUIS, T. R. R. ASSN. OF ST. LOUIS.



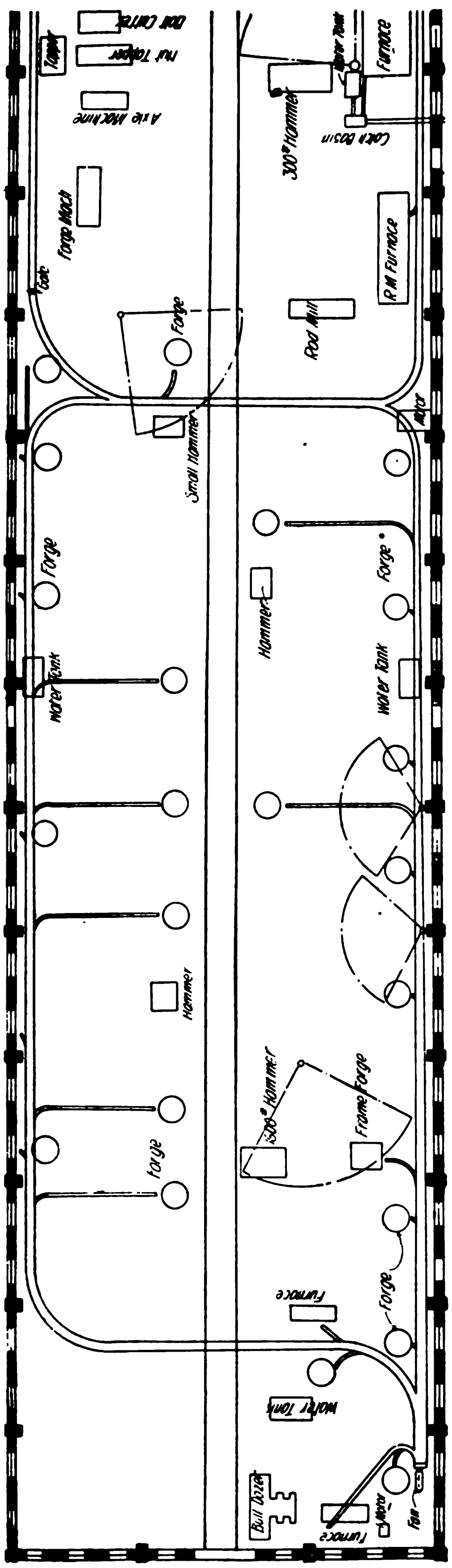
PLAN OF BLACKSMITH SHOP, SHOWING LAYOUT OF EQUIPMENT AT SILVIS, ILL., C., R. I. & P. RY.



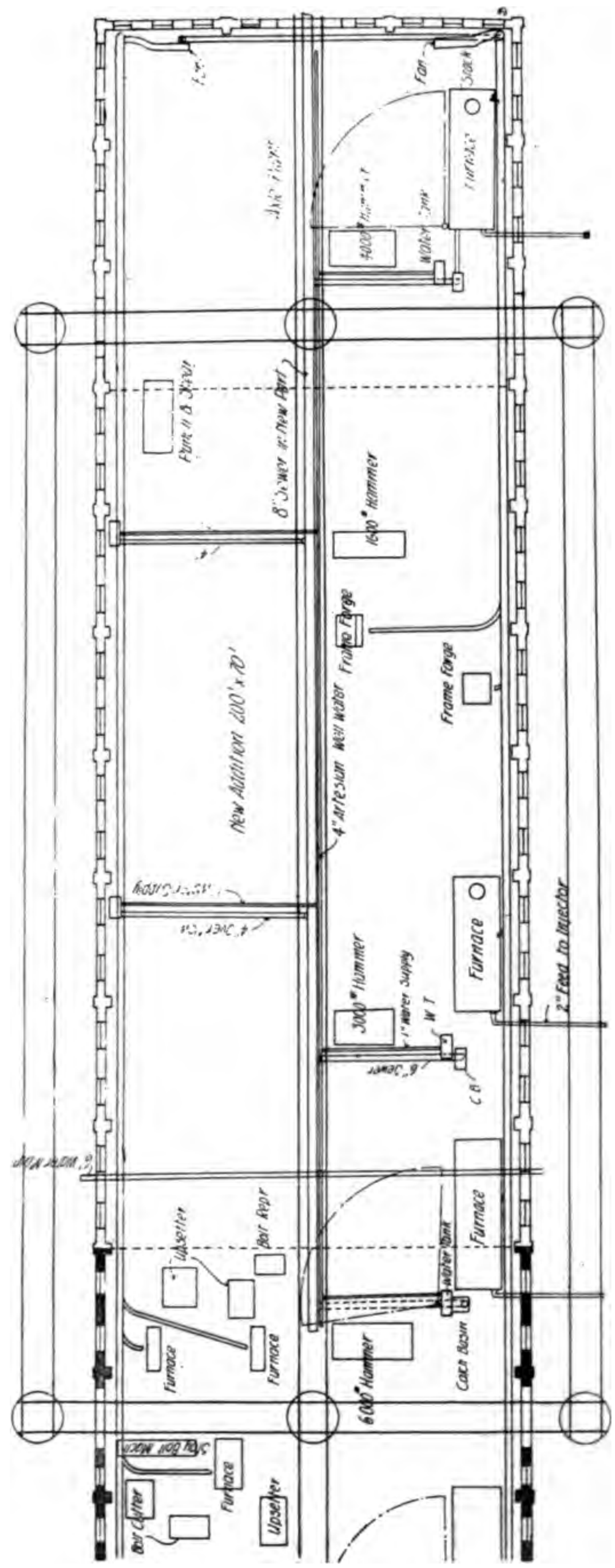
PLAN OF BLACKSMITH SHOP, SHOWING LAYOUT OF EQUIPMENT AT READING, PA., P. & R. R. R.



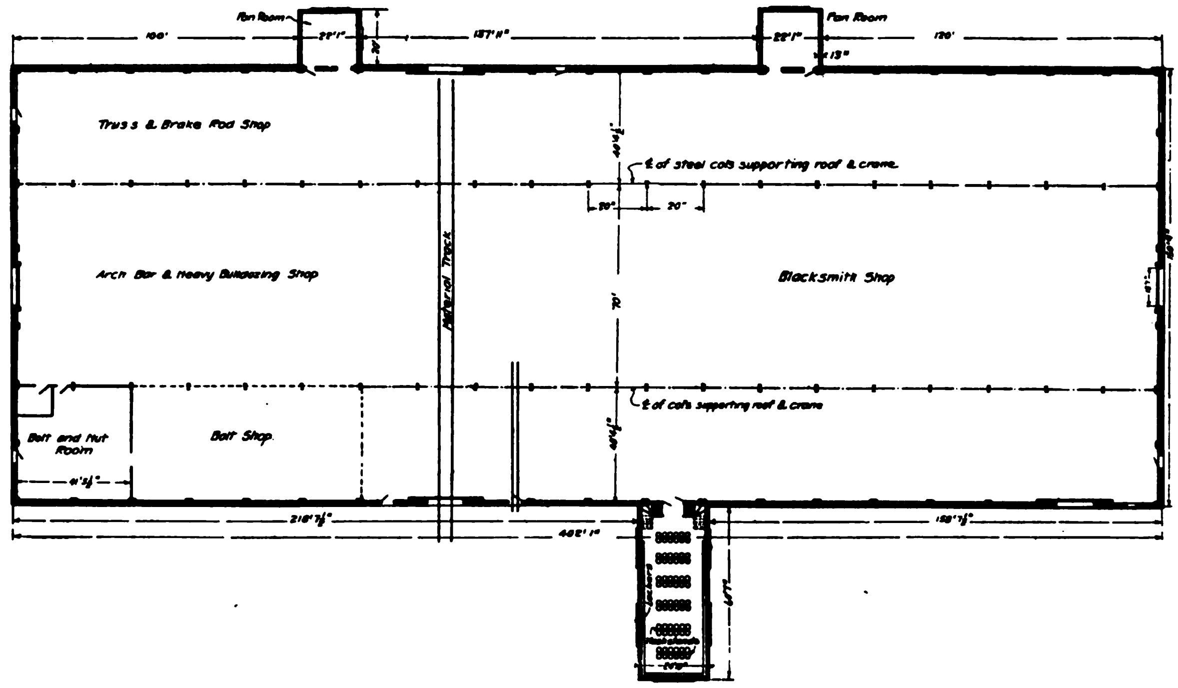
PLAN OF BLACKSMITH SHOP AT COLLINWOOD, O., L. S. & M. S. RY.



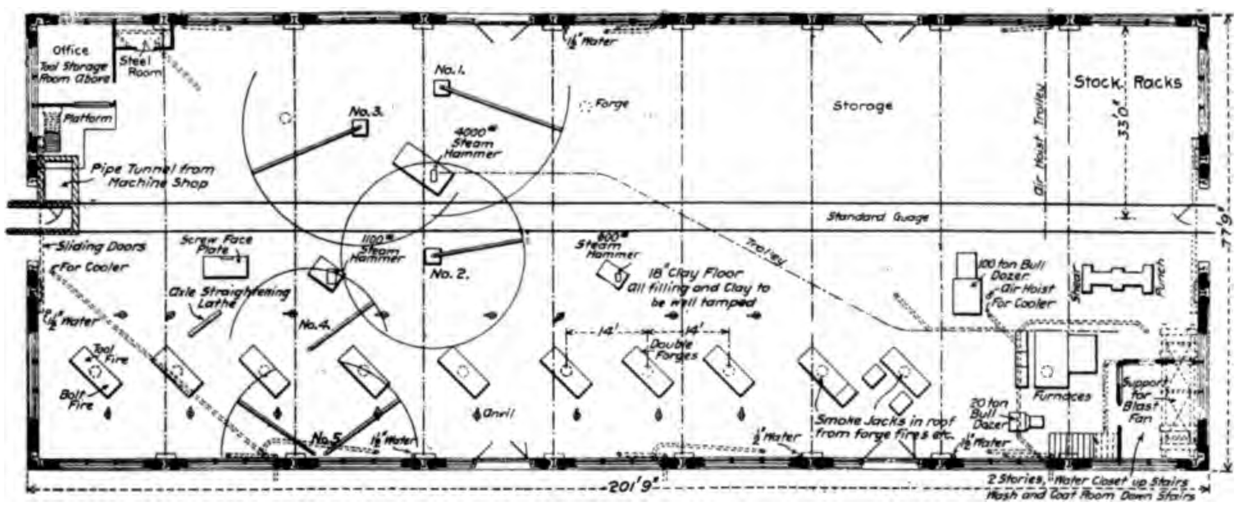
PLAN OF OLD SECTION OF BLACKSMITH SHOP AT MILWAUKEE, WIS., C., M. & ST. P. RY.



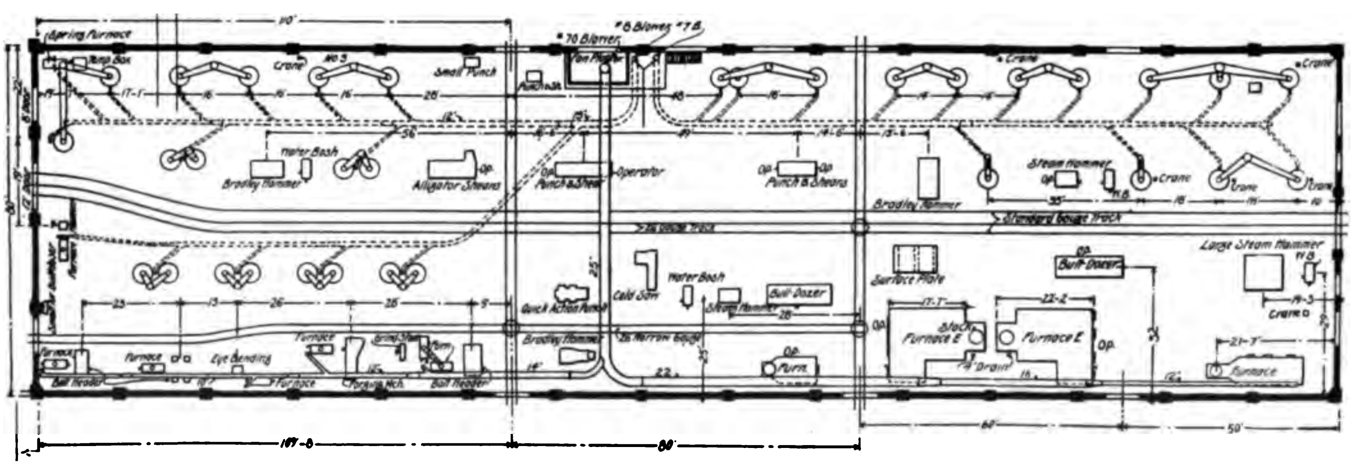
PLAN OF ADDITION TO BLACKSMITH SHOP AT MILWAUKEE, WIS., C., M. & ST. P. RY.



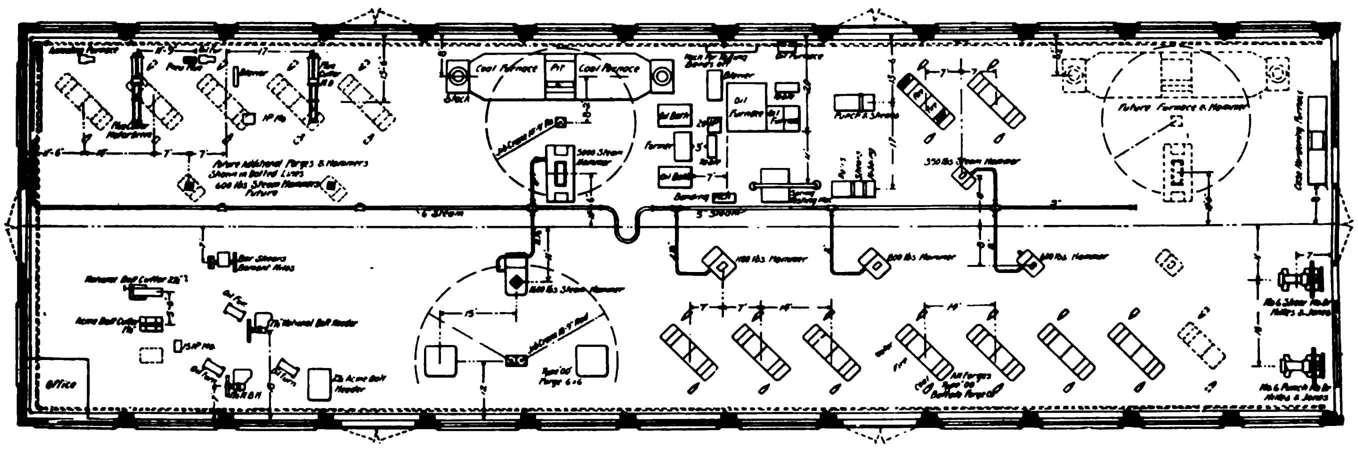
PLAN OF BLACKSMITH SHOP AT SOUTH LOUISVILLE, L. & N.R. R.



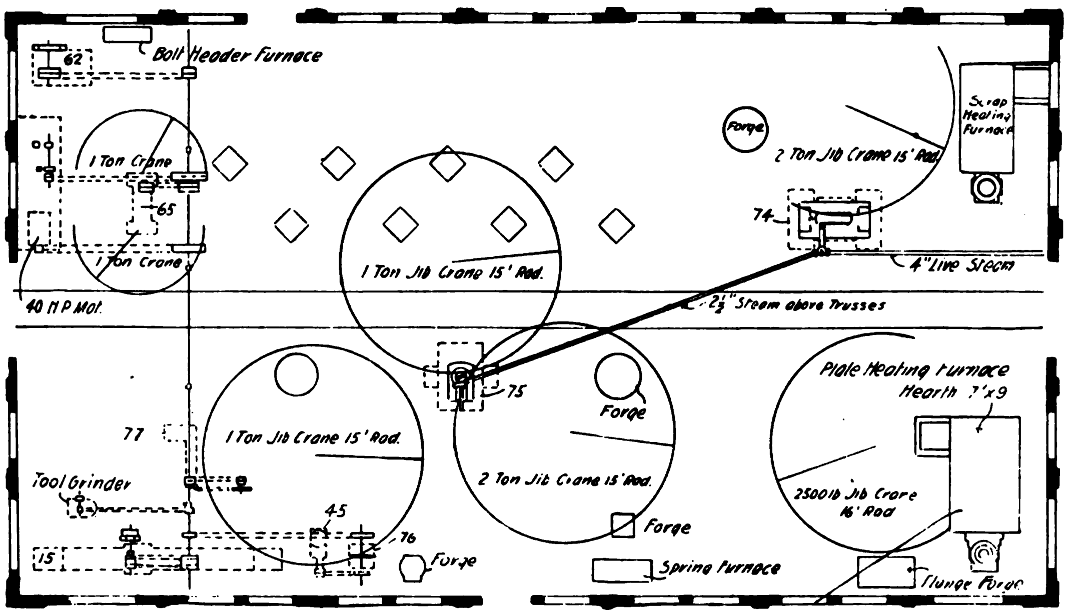
PLAN OF BLACKSMITH SHOP AT M'KEES ROCKS, P., & L. E. R. R.



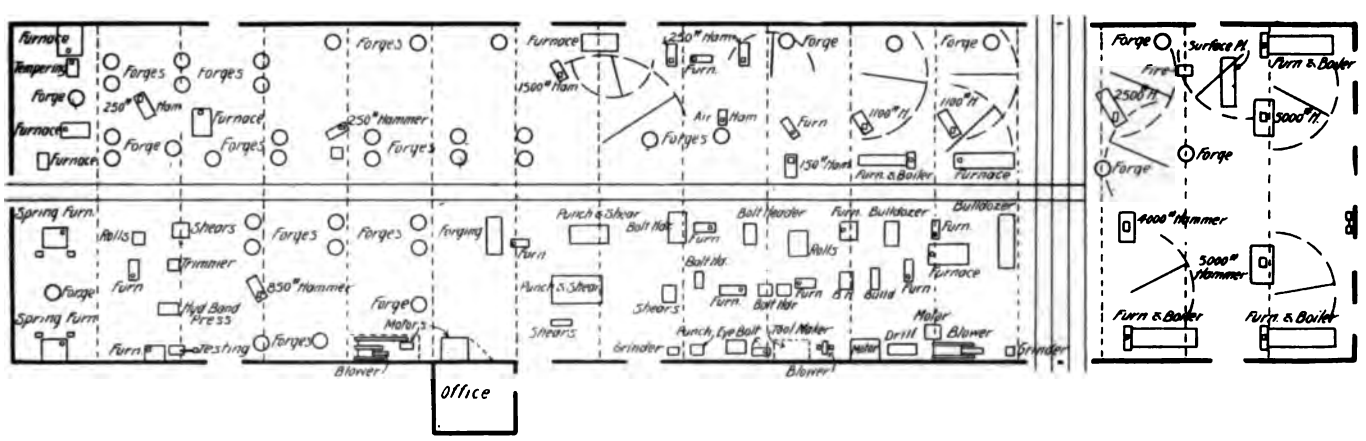
PLAN OF BLACKSMITH SHOP, SHOWING LAY-OUT AND ARRANGEMENT OF MACHINES AND FORGES AT SCRANTON FREIGHT CAR SHOPS, D., L. & W. R. R.



PLAN OF BLACKSMITH SHOP, SHOWING LAY-OUT OF EQUIPMENT AT TRENTON, N. J., P. R. R.



PLAN OF BLACKSMITH SHOP, SHOWING LOCATION OF EQUIPMENT AT DU BOIS, B., R. & P. RY.



PLAN OF BLACKSMITH SHOP, SHOWING LAYOUT OF EQUIPMENT AT TOPEKA, KAS., A., T. & S. F. RY.

Railway Shop Up to Date

Chapter V.

FREIGHT CAR SHOP

THE freight car department includes the equipment for the construction of new cars, heavy repair work, and light or running repairs to cars. Provisions for these several classes differ to some extent at the shops of the various railway systems. At the Angus shops of the Canadian Pacific Railway, practically all freight car work is confined to the construction of new cars. The shops at Angus include a locomotive department and a passenger car department, as well as that for freight car work. The Keyser Valley shops of the D. L. & W. Railroad at Scranton, Pa., are operated almost exclusively for the construction and repairs of freight cars and include no other departments. The Wabash Railroad has built new car shops at East Decatur, Ill., to provide for the repair of both passenger and freight car equipment. The Readville, Mass., shops of the N. Y. N. H. & H. are operated for the maintenance and repair of both freight and passenger car equipment, and the Sedalia, Mo., shops of the M. K. & T. Ry. are operated entirely for car work.

LOCATION.

The majority of American shops include both locomotive and car departments and the several buildings of each shop plant are placed according to requirements for the most economical operation of the plant as a whole.

Inasmuch as the freight car shop is an assembling point for a large amount of material, both wood and metal, the principal features are its location with regard to delivery, ample storage space adjacent to the shop and facilities for the rapid handling of material in large quantities.

In view of the large amount of material assembled, communication with the several auxiliary or sub departments, should be direct and convenient, for instance, from the mill, storage yard, truck shop, car machine shop, blacksmith shop and foundry. Where a single foundry serves both the locomotive and car department, its location near the locomotive shop is preferable inasmuch as heavier castings go to the locomotive shop and the smaller castings of the car department are more easily delivered in bulk over the greater distance.

The freight car repair shop is usually adjacent to the freight car repair yard or covers a portion of the yard tracks. This provides for minimum amount of switching of bad order cars and locates both heavy and light repair work adjacent to the same base of supplies.

BUILDING.

The structural work of the freight car repair shop is comparatively simple. The principal requirements are a long narrow building, protection for men and equipment against the weather and ample natural light.

The modern freight car shop is similar to the other principal shop buildings in being constructed with a steel skeleton and brick walls. The introduction of heavier cars, both wood and steel, makes overhead cranes desirable in at least a portion of both the freight car repair shop and the shop for erecting new cars. With the larger cars of today, the cost of construction and maintenance is increasing, so that the need of cranes and other facilities for the economical operation of the shop is felt.

By arranging four longitudinal tracks on 20-foot centers and so placing them that the centers of the outer tracks will be 15 feet from the faces of crane columns, a span of 90 feet may be had for the crane. Assuming that it is desired to provide a standing capacity of 80 cars, a floor area of 90,000 square feet would be required. Allowing 50 feet per car, the length of each track would be $50 \times 20 = 1{,}000$ feet. With four tracks arranged on 20-foot centers and with 15 feet from centers of outer tracks to face of columns, the width of floor between columns would be $(3 \times 20) + (15 \times 2) = 90$ feet and 1,000 (length of track) x 90 (width of floor) = 90,000 square feet, area of floor.

A feature very necessary for the construction of new cars is ample entrances to the building by which delivery of material may be made.

ARRANGEMENT OF TRACKS.

It is generally conceded that longitudinal tracks are the most satisfactory, both for the erection of new cars and the repair of old. Such an arrangement provides a feasible method of handling cars in strings, and lends itself most readily to an economical distribution of material due to the large amount of comparatively light material to be handled and to the frequency with which one car is replaced by another on the same working space.

Some shops still in existence would indicate that several years ago there was a question as to the most desirable arrangement of tracks. However, such shops are confined principally to the smaller and older ones, and the more recently constructed are almost uniform in providing longitudinal tracks for freight car work. Those plants at which the principal departments are served by a single transfer table, as well as some others of a different general layout, include a transverse freight car shop to which access is usually had by a system of ladder tracks at the side of the shop opposite the transfer table, as at the Colorado and Southern shops at Denver, the Wisconsin Central at Foud du Lac, the Oregon Short Line at Pocatello, the Missouri, Kansas and Texas at Sedalia and others. At the Oelwein shops of the

Chicago Great Western access to the freight car shop is by the transfer table only. At the Collinwood shops of the L. S. & M. S. Railway the freight car shop was originally in a building in which the tracks are arranged transversely and are served by a transfer table. This building has since been assigned to caboose repairs and other work and a new longitudinal shop has been erected.

The freight car shops and yards recently built indicate that a distance of 20 or 22 feet between centers, with an even spacing between the tracks throughout, is found most satisfactory.

Some yard tracks for light repairs are placed evenly on 16- to 20-foot centers, while the yard tracks for heavy repairs and those in the shop are spaced from 20- to 22-foot centers. Usually with this arrangement, material tracks are placed in each space between tracks.

At other points the working tracks are grouped in pairs on centers from 16 to 20 feet, and the groups are spaced from 20 to 26-feet apart with material tracks between the groups.

Where the even spacing prevails the tracks are from 20 to 22 feet between centers with usually a distribution track in every alternate space.

INDUSTRIAL TRACKS.

While narrow and standard gauge distribution tracks are both in use, the standard gauge now meets with greater general favor for the industrial system of communication and delivery. This system provides greater scope for the movement of push-cars, as it allows of their transportation over any of the tracks of the yard and the standard track facilitates the delivery of mounted wheels. While using standard gauge, material tracks are frequently made up of lighter rails than those used in working tracks and road tracks.

METHODS OF OPERATION.

In the construction of new cars the most economical operation, for the assemblage of large quantities of material and for the erection of cars in stages by gangs of specially trained men, provides for the advancement of each car from one stage to the next in regular sequence. In accomplishing this result trucks, sills and other material from the auxiliary shops are delivered at one end of the erecting shop where erecting work is begun and as the stages of construction advance, each car is pulled forward. Thus there is a string of cars in different stages of construction advancing along each longitudinal track, until, at the opposite end of the shop, each car is delivered, complete, painted and ready for service.

A satisfactory method of moving a string of cars as the work of construction progresses is to locate a motor, or motors, at the end of the shop to which the finished car advances, provide coupling rods for coupling the cars of a length standard to the shop, and pull each track as the work requires. By installing a shaft located beneath the floor and suitable clutches, together with a drum at each track, one motor will serve four or six tracks. The motor for this purpose is sometimes placed in a cabin beyond the end of the shop, but its location within the shop would seem the more desirable.

A coupling rod about 10 feet in length is recommended. This keeps the cars separated a certain distance at all times and allows free movement among the cars, a feature which is especially desirable in the vicinity of doors in the sides of the shop for the delivery of material from the storage yard. In a shop of great length, much material is delivered through side doors instead of at the end where construction work begins, thus economizing in the delivery of material by shortening the distance between points of storage and assemblage and reducing time consumed in delivery.

Consistent with ample storage space is the provision for classifying and piling material. Rods for framing of box cars may be ordered in required lengths and when threaded, sorted and stored in racks, the rods are made to follow the most direct route from the storage pile to the car. Such racks should be carefully stenciled with the length and diameter of rod, so that laborers in transferring material can make no mistake. This system also provides a simple means by which a store department clerk may readily determine an estimate of the amount of material of each size on hand.

A similar plan may be applied to the classification and storage of the various castings which enter into car construction. This method not only classifies the castings and keeps them together, but requires much less time in storing them, in that they may be dumped into bins from the trucks of the industrial system, whereas the time necessary to pile and segregate small pieces is decidedly wasted.

The same plan applies well to the distribution of bolts, nuts, cotter keys, washers, lag screws, nails, etc. For bolts and nuts large bins may be provided and as a truck load is delivered the boxes may be dumped directly into the bins. This plan serves to classify and store bolts and nuts in a place where a given size is always to be found duly labeled. It further removes the unsightly piles which are difficult to maintain and segregate.

The most economical method of distributing small material is to handle it in bulk, either in small wagons specially designed for the purpose or in sheet iron boxes arranged to be handled by light cranes as well as by trucks.

The latter arrangement lends itself readily to the method of storing bolts, nuts, etc., in bins, for the boxes may be handled by air hoists in transferring them from the trucks to the bins. Where this method is followed the bins are served by traveling air hoists. Bins for bolts are not covered so that material may be delivered over side partitions. To facilitate getting in and out of these bins when the stock is low, a wooden strip is nailed along the outside and on the inside an old grab iron is bolted in order that workmen may climb in and out of them conveniently. The

bins in which nuts, washers, cotter keys, lag screws, etc., are stored are equipped with hinged covers and these covers are locked after the bins have been filled. A hole in the side partition near the floor provides a means for workmen to get at stock. A little thought concerning the large number of kegs which would be required for the storage of nuts, nails, etc., for a shop turning out, say 28 to 30 cars per day, will show the advantage obtained by storing this material as described.

CANADIAN PACIFIC—ANGUS.

The freight car erecting shop of the Canadian Pacific Railway at Angus has been used exclusively for the construction of new cars. It is located at one edge of the area devoted to shop buildings and is tributary to the "Midway," or avenue of distribution which traverses the entire shop area and is served by an overhead traveling crane as well as by standard gauge tracks the industrial system. The car erecting shop is directly across the midway from the mill building. Next to the car erecting shop is the truck shop; while the car machine shop is just beyond. The lumber yard is so situated with regard to the mill building, and the blacksmith shop, car wheel foundry, etc., are so placed with relation to the car machine shop and truck shop and the storage yard is so disposed around the car erecting shop, that material entering into the construction of cars advances from the several sources of supply and through the various departments in regular sequence, to the point of assemblage.

The shop building is 540 feet long by 107 feet wide and is well lighted naturally. It is divided into two bays and there are three standard tracks in each bay, two of which are used for erecting work and the central track is kept open for the delivery of material throughout the shop. The tracks in each bay are spaced evenly at a distance of fifteen feet between centers. Between the centers of the adjacent tracks of the different bays is a distance of 20 feet.

The erection of cars is begun at the end of the shop near the Midway, where trucks are delivered from the truck shop. A portion of each bay near this end of the shop is served by three traveling cranes driven by air and operated by hand from the floor. In the construction of box cars the roof frames are built on the car decks and are then hoisted by these cranes while the supporting frame is constructed between them. As the work of construction progresses the cars are gradually moved to the further end of the shop in order that each gang of men may handle that class of work at which they are specialists. The first gang applies sills and draft rigging, the deck is applied by the second gang, the roof and frame by the third, and so the car proceeds until it is finished at the further end of the shop. The cars are hauled forward by a motor at the end of the shop.

Bolts, nuts, washers, lag screws, etc., are stored in bins to facilitate storage and classification. In the storage yard along one side of the erecting shop, is a system of bins for the storage of small castings. In the storage yard on the opposite side of the shop a number of forgings, castings, springs, etc., are stored and it is intended to provide for this storage by constructing a long shed about 40 or 50 feet from the building to protect this material from snow in winter.

The paint shop is practically a continuation of the erecting shop and is separated from the latter by a fire wall and rolling steel doors. Cars are handled through this shop by motors as described for the erecting shop.

In this connection it is appropriate to call attention to the advantage provided by the location of the paint shop in such relation to the erecting shop, an arrangement which seems far superior to that which exists in some other railroad shops where it is necessary to transfer and switch cars over several tracks in moving from the erecting to the paint shop.

Tracks beyond the paint shop provide a standing capacity for about the same number of cars as the paint shop and during the summer months a large portion of the cars are painted outside on these tracks.

At Angus freight cars are painted with air machines.

D., L. & W.—SCRANTON.

The Keyser Valley shops of the D. L. & W. Railway at Scranton are devoted almost entirely to the construction and repair of freight car equipment. In addition to other facilities, the shop plant includes a car erecting shop, a car repair shop for heavy repairs, and a repair yard for light repairs.

The car erecting and repair shops are similar in size, construction and arrangement, except that the central bay of the erecting shop is served by a 15-ton traveling crane and contains some equipment for the construction of new cars, while the car repair shop is not so provided

Each building is 400 feet long by 150 feet wide and has a capacity of 48 cars. The buildings are of brick supported by structural steel frame work, and while they are plain as regards architectural embellishment, they present a very neat appearance. They are extremely well lighted by natural light, ample space between buildings aiding in this particular. In addition to the ordinary windows, which are large, much of the wall space above is fitted with window sashes, which adds much to the diffusion of light throughout the interior. Above the centers of the roofs are monitors which extend nearly the full length of the buildings and the sides of these monitors are equipped with glass lanterns. Saw-tooth skylights are placed at intervals along the roof. All glass surfaces are vertical with the exception of those in the skylights, so that there is very little opportunity for discomfort to be caused by direct rays of the sun pouring down upon the floor beneath.

Each building is divided into three bays. In the main, or central bay, there are two standard gauge tracks extending the full length of the building and

connected with yard leads. These tracks are arranged on 22-foot centers and in each side bay are two working tracks, similarly spaced. The adjacent tracks of the different bays are spaced 24 feet between centers. The center bay is served by three narrow-gauge tracks. In the side bay one narrow-gauge track is between the two working tracks, while the other distribution track is between two outer tracks and the wall. The floors are of concrete.

In the yard for light repairs about 250 or 300 cars are repaired per day. This yard contains eight tracks arranged on 20-foot centers, and in every alternate space between working tracks is a narrow-gauge track of the industrial system. In this yard one track is reserved for the repair of steel cars.

For convenience in storage and delivery of material the yard contains a series of long, narrow material sheds in which are kept bolts, nuts, finished lumber, sheathing, car doors, couplers, etc.

There are two scrap platforms, or docks, near the repair yard for the accumulation of scrap material gathered from cars undergoing repairs. Each one is equipped with air operated shears, and the various kinds of scrap are assorted into classified bins. The platforms are level with a car floor and industrial tracks traverse the length of each platform.

The freight car repair shop is situated near the mill building and the centers of distribution, where sills and other comparatively heavy material may be delivered conveniently. Beyond the fact that cars held for heavy repairs are repaired under cover, there is practically little difference between the work done here and that at the average yard.

The greatest interest centers in the freight car erecting shop, where the bulk of the material from the various shops and sub-departments is assembled. At the time that work was begun on a large order of box cars having underframes reinforced with steel frames of commercial shape, the erecting shop was equipped to handle steel and other work economically, and it is interesting to note the methods followed.

In ordering steel for the construction of this framing, the practice of the company is to purchase proper lengths for the various parts. This material is delivered either in the yard at the end of the shop or just within the shop.

Both side bays are equipped with scaffolds suspended from the roof trusses to facilitate work on the superstructure. In the center way, served by a crane, trucks are erected, the steel reinforcing frame is assembled, sills are mounted and decks laid. In the side bays box frames are erected, roofs built, sheathing applied, trimming work is done, and before leaving the shop one coat of paint is applied.

A drill press and a punch and shear are located in the end of one side bay nearer the machine shop. In the same end of the main bay are air-operated riveters, portable forges and other equipment for assembling the reinforcing frames, for riveting couplers, yokes, etc.

Over a portion of one track in the main bay is a raised track supported on cast iron pedestals. Trucks are erected on this raised track and the arrangement provides facility for the truck erecting men in getting at bolts.

One end of this raised track is inclined to a height sufficient to reach the deck of a flat car. Cars loaded with wheels are switched into the shop and delivered to a point at which wheels can be unloaded easily over this incline.

When trucks have been completed they are piled one above the other by the crane, in order that they will occupy minimum floor space until required. This provides a convenient method of storing trucks in an accessible location when the supply exceeds the demand, and when needed they are readily delivered by the crane to the car erecting track.

During the erection of trucks, bolsters are delivered by the crane, so that truck erecting men have practically no handling of bolsters.

All parts of trucks, bolsters, sand planks, arch bars, boxes, brasses, bolts, etc., are delivered by laborers within easy reach of erecting men, so that work of erection progresses rapidly and without unnecessary interruption.

In drilling and punching the several I-beams used in the construction of the reinforcing frames, the webs are punched according to forms. Holes are then laid out according to templates and pass to the drill press, whence they are delivered to the riveters. A portion of flanges on draft beams are sheared off to provide for application of couplers, and this work is done cold.

Angle irons, queen posts, malleable castings, etc., are riveted by air riveters and the parts pass to the assembling gang.

To provide convenience in forwarding this work rapidly and at the same time insure accuracy and proper angles, the frames are constructed on specially designed tables, two of which are provided in this end of the shop in order that two reinforcing frames may be constructed at one time. These tables are illustrated by line drawings presented at the end of this chapter.

Upon completion the frames are transferred by the traveling crane to the center of the shop or to the further end, where they are lowered upon the trucks which are previously placed in proper position to receive them.

Frames are transferred by a specially designed carrier hung from the crane hook. The carrier is composed of 9-inch channels, 15 pounds per foot, 24 feet 11 inches long, having a chain attached to its center for connection with the crane hook and a chain at each end to which the frame is secured. When not in use this carrier is stored at some point on the floor near the frame erecting tables.

After the reinforcing frame is placed on the trucks, sills are applied, brake rigging attached, deck nailed down and frame castings placed on deck before the car is moved.

Following this work, cars are pulled out of the main

bay by an electric motor located in a shanty near the main bay lead and about 300 feet from the shop building. In good weather decks are nailed down after cars have been pulled out of doors.

Cars are switched by yard engines from the main bay lead to the side bays, where the erecting work is finished as before described.

Sills are transferred from the mill to the erecting shop on industrial cars and inside the shop they are handled by the crane. When laying the sills the crane is again used. Castings entering into car construction are brought in from the storage yard in wheelbarrows and placed where they will be conveniently loaded upon the cars. Air brake cylinders and rigging are started near the point of erection so as to avoid further transfer when ready for application. Lumber for sheathing frames, purlines, roofs, etc., are delivered from the mill to the erecting shop in carloads and placed in side bays easy of access to the various cars under construction. Where such lumber is delivered when partially finished cars are standing either in the main bay or on the outside leads, it is placed on the truss rods so that it will be transferred with the car in its movement to either side bay for completion.

The car repair and erecting shops are situated side by side with a distance of 70 feet between them. The freight car paint shop is situated a distance of 166 feet beyond the ends of these shops and on a center line passing midway between them. Cars are transferred from the erecting shop to the paint shop by the yard engine, and by the time a car has been switched from the central bay of the erecting shop to the side bay and again to the paint shop, it would seem to have been moved several times unproductively.

While the shop under discussion has many points of advantage and is well equipped, it would seem that an arrangement whereby a car advances from one stage of construction to the next without doubling in its course would give greater output.

N. Y., N. H. & H.—READVILLE.

At the Readville car repair plant of the New York, New Haven & Hartford Railroad, the freight car repair shop is situated between two car repair yards and spans the track extensions of these yards. The shop is 350 feet long and 160 feet wide and has a standing capacity of 60 cars. The tracks in the shop and yards are spaced on 20-foot centers. The yard at the east end of the shop will accommodate about 500 cars at one time. Cars enter through the yard at the east end and move progressively through the shop and out at the west end.

The location of the shop and yards with reference to the other buildings of the plant is such that raw material may be delivered easily from the various sources of supply and other departments.

The freight car erecting shop is a brick building in which the roof trusses and supporting columns are of yellow pine. The columns supporting a second floor at one end of the building are of cast iron. The roof of this portion is covered with slate, while the remainder is covered with eastern granite roofing. Natural day lighting is provided for by large windows in the side walls and by sashes in the end doors. The flooring is of concrete.

L. & N.—SOUTH LOUISVILLE.

At the South Louisville locomotive and car plant of the Louisville & Nashville Railroad the freight car repair shop is situated between a storage yard having a capacity of 325 cars and a repair yard capable of standing about 50 cars. The building is 400 feet 7⅜ inches long by 145 feet wide and contains six working tracks spaced 20 feet between centers, as well as a material track which extends along one side of the building. The shop has a standing capacity of 60 cars.

With the exception of two, the tracks in the yards are continuations of those in the shop and are spaced the same distance apart.

The shop for the construction of new cars is tributary to the transfer table and is situated next to the mill building. The building is 300 feet 7⅜ inches long by 134 feet 8 inches wide. It contains six working tracks arranged in three groups, with two working tracks in each group. The working tracks of each group are spaced 20 feet between centers and the adjacent tracks of the different groups are spaced 22 feet 6 inches between centers. Between the working tracks of each group is a material delivery track of standard gauge. This shop has a capacity of 42 cars.

Both the freight car repair and erecting shops are of steel construction with side sheathing of corrugated iron.

In the erecting shop for new cars the bays in which the working tracks are situated are separated by the rows of columns supporting the roof trusses. The ends of the building are covered with corrugated galvanized iron to within 16 feet 9 inches of the ground, and the sides are of the same material to within 10 feet of the ground. Both the sides and ends of the building are equipped with rolling steel doors. Above the roof over the center of the main bay is a monitor extending the full length of the building, the sides of which are equipped with glass lanterns. A row of skylights, placed at intervals, extends along the roof above the center of each side bay. Above the corrugated iron sheathing much of the wall space is fitted with stationary window sashes. The building is covered with a composition roofing and the floor is of concrete with a granitoid finish.

The scaffolding for the building tracks are of permanent construction and are suspended by angles hung from the roof trusses. The platforms are 4 feet wide and are situated about 7 feet above the floor. The platforms are provided with extensions 2 feet 6 inches wide on each side, which are so hinged that they may be swung out of the way when not in use. When in use the extensions are held in position by ¼-inch wire rope cables secured to the roof trusses.

Ordinarily, erecting work is done on three of the working tracks at one time, while material is being brought in and placed conveniently for the other three.

If necessary, however, all six tracks may be used at the same time. In such an event maximum output would be obtained by delivering material at night.

Car sills and the larger material from the planing mill are delivered to the erecting shop over the transfer table, while the lighter material is delivered direct by push cars. Trucks and other material pass to the shop in sequence and are delivered direct to the shop from the transfer table, much of it being delivered to the table by the yard crane which serves the storage yard located at right angles with the transfer table pit. Much of the small material delivered to the erecting shop, such as bolts, nuts, washers, lag screws, etc., is stored beneath the scaffold platforms along the sides of the shop. Larger and heavier surplus material is stored between the tracks, just outside of the shop at the end further from the transfer table.

While the cross-section of the freight car repair shop is very similar to that of the erecting shop for new cars, the building is lower and the arrangement of trusses is different. The roof trusses are supported by a single row of columns and the shop is divided into two sections only. The arrangement of glass in the monitor, skylights and stationary side sashes is similar to that of the erecting shop. The sides and ends of the building are equipped with rolling shutters. The floor is of cement with a granitoid finish. In alternate spaces between pairs of tracks are air connections attached to hose extending from an air system carried along the roof trusses.

The foreman's office is situated in the northwest corner of the building and is elevated at such a position as to furnish a good view of the interior of the entire shop as well as over the freight car repair tracks. Along the west side of the building is a long platform or balcony for the workmen to store their tool boxes. A row of work benches is located along the east side of the shop. Stoves are situated at different points throughout the building to provide means for the men to warm themselves during severely cold weather.

In both the repair and erecting shops the natural day lighting is ample and is well distributed.

WABASH RAILROAD—EAST DECATUR.

At the new East Decatur shops of the Wabash Railroad no large provision has been made for repairing freight cars under roof. The climate is comparatively mild at this point, and due to the almost complete absence of snow it is possible to repair freight cars out in the open most of the year.

The repair yard is situated at the extreme south side of the plant and contains four working tracks. The tracks are arranged in two groups, those of each group being spaced on 20-foot centers. Each group is served by a material track located between the working tracks, and a third material track passes near the adjacent shop buildings. Between the two groups of working tracks are three material racks 56 feet long by 8 feet wide. The repair tracks have a capacity of 170 cars.

The shop plant includes a large repair shop 463 feet long by 88 feet wide, containing four longitudinal tracks spaced 20 feet between centers. Though this shop is intended principally for passenger coach repair work, a portion of it may be used for heavy repairs to freight cars during bad weather.

C. C. C. & ST. L.—BEECH GROVE (INDIANAPOLIS).

At the Beech Grove shops of the Big Four Railway, situated near Indianapolis, the freight car repair yard is adjacent to the main freight switching yards, so that the switching of bad order and repaired cars will be reduced to a minimum. The freight car repair shop, 403 feet by 156 feet, is approximately at the center of the south edge of the repair yard. The working tracks through shop and yard are spaced alternately on 18-foot and 22-foot centers. In the wider space between tracks a narrow-gauge track is installed for the delivery of material.

P. & L. E.—M'KEES ROCKS.

The freight car repair shop of the Pittsburg & Lake Erie Railroad at McKees Rocks, Pa., is a brick and steel structure 654 feet 7 inches long by 154 feet wide, arranged in three longitudinal bays. An extension on the east side of the shop, 23 feet wide by 450 feet long provides a convenient location for the furnaces, straightening presses, storage rooms, and machine shop.

The walls are of brick with steel framing conforming to the uniform design of the other shop buildings. The roof is of saw tooth construction with transverse skylights, and is supported by steel trusses resting upon steel columns. The windows in the skylights are vertical and face toward the north so that an abundance of light is admitted to the shop from above. Large windows in the side and end walls also contribute materially to the natural lighting.

The hot air system of heating is installed, with overhead supply pipes and down drop outlets. The shop is piped with both air and natural gas, for the operation of tools and heaters.

Two of the three longitudinal bays are devoted to the repair of wooden cars, while the third or east bay is given over entirely to steel car work. In each bay are two longitudinal working tracks on 24 foot centers, with a standard material gauge track located centrally between them. The centers of the two outer tracks are 14 feet 3 inches from the crane columns and the center of the inner tracks 12 feet from the main columns, allowing ample space for carrying on repairs simultaneously on all tracks, without confusion or interference. The span of each outside bay is 53 feet and that of the center bay 48 feet, with a clear height from floor to roof truss of 30 feet. Each bay is served by an overhead electric crane operating the full length of the shop, the crane in the west bay being of 40 tons and those in the other bays 20 tons capacity each.

The wood working shop and lumber storage house are located adjacent to the main shop, on the west and are arranged for direct handling of material. A system of standard gauge material tracks provides a convenient method for the distribution of material from one building to another. The store room, although located a greater

distance away than the mill, is easy of access and through the system of material tracks is provided with a ready means of communication with all departments. The scrap platforms and bins are located beyond the store house. The platforms are level with a car floor for convenience in loading and unloading scrap, while a material track extends the length of the platform for handling the scrap from the shop.

According to the practice common to longitudinal shops, cars undergoing repairs advance progressively. Bad order cars enter the north end of the shop and as repairs are made they are moved toward the south end where the finished cars leave. In this shop repair men are not organized in gangs of specialists assigned to certain classes of work, but each gang is capable of making all classes of repairs. Thus a gang assigned to a car entering the shop is held responsible for all repairs marked up against the car. All air brake work, packing journal boxes and a few other special jobs are assigned to regular men. While up to date practices are followed throughout the shop there is nothing absolutely distinctive in the methods of repairing wooden cars.

The bay devoted to the repairs of steel cars provides space under cover for 30 cars, assigning 15 cars to each working track, and approximately 43 feet is allowed to each car. The machine shop extension practically constitutes a separate bay adjacent to the east bay, so that direct access is afforded to all machines, furnaces, etc. At the south end is a large oil furnace for heating bent parts.

When a large number of bent parts has accumulated they are heated in the furnace and straightened on the table or by presses provided. Near the furnace is a coke fire for heating the rush parts which are necessary to prevent delay to the movement of cars. A large pneumatic press is within convenient reach of the furnace and dies are provided to fit all regular repair parts. For straightening angles, beams, stakes, etc., is a large pneumatic press. Adjacent to this press is a horizontal pneumatic riveter, for riveting all parts which can be conveniently handled. Beyond the riveter are the storage rooms, containing a stock of end sills, extension center sills, side stakes, buffer plates, center pockets, structural iron, etc. At the north end of this bay a carpenter and pipe shop are partitioned off and equipped with the necessary tools. An overhead trolley line crane and 2 hand cranes operate the full length of the machine shop and storage room, on a line of 10 inch I beams, suspended about 12 feet above the floor. This provides an easy method of handling material undergoing repairs and also for the delivery of heavy parts in stock. This bay is well lighted by windows and has a plank floor similar to that in the remainder of the shop.

The ordinary service of a car in the ore and iron trade in the Pittsburg district is much shorter than in other localities and the severe handling which cars are subject to, makes it necessary to give heavy repairs to a large proportion of those going to the shops. Common causes for shopping steel cars are derailments, cornering, etc., which distort or twist the body. Repairing a car in this condition is generally a slow and expensive operation. To meet the requirements of this class of repairs a steel car repair frame has been erected. The design and construction of this frame are original and its operation is unique. The frame is of steel construction, firmly secured upon a concrete foundation. It supports a number of screw jacks which may be adjusted readily in various positions. The frame is so strongly constructed and so carefully devised that a steel car having a twisted body may be jacked into shape without removing the body from the trucks. Actual service tests have demonstrated that by this method of straightening steel cars a saving of 400 hours per car is effected.

The jack frame is built of 12-inch channels arranged in 5 pairs forming a skeleton steel box. Horizontal braces of 12-inch channels riveted to the tops of the vertical members bind them firmly together. Diagonal braces of 3 by 2 inch angles and longitudinal braces of 6 by 6 inch angles, connect the five sections of the frame. A system of braces at the lower end of the vertical members similar to that employed at the upper ends completes the structure making a frame work having a width inside of 13 feet, height of 11 feet 6 inches and a total length of 30 feet 9⅞ inches. The vertical and cross channel members are arranged in pairs 3¼ inches apart and form the supports for screw jacks of special construction which may be adjusted at any place and clamped in position.

ISOLATED REPAIR YARDS.

In view of the economy and advantage of keeping the number of bad-order cars at a minimum, a word in behalf of the isolated repair track seems appropriate. The facilities afforded for the repair of freight equipment at isolated points are, in most cases, totally inadequate. The fact that a repair yard is not near a shop makes it all the more necessary that such a point should be well equipped with tools and facilities as well as a generous store of those parts apt to be required on short notice.

On most roads the freight cars held for repairs each day average from 2 to 3 per cent of the total equipment owned, but if the "bad orders" increase to over 3 per cent, the situation becomes serious and calls for special attention.

Much that concerns the equipment and facilities of isolated repair yards applies as well to the terminal repair yards and those run in connection with building and repair tracks. The importance of good facilities is quite frequently underrated, and it is difficult to estimate the loss of car service resulting from inferior repair facilities.

Among the items of most importance for the prompt repair of freight cars are a sufficient supply in convenient locations, of all standard kinds of car repair material, such as bolts, castings, mounted wheels, framed timbers, etc.; it is almost equally important to have good facilities for handling material between the point of storage and the cars to which the same is to be applied.

For this purpose material tracks with push cars running between the car repair tracks are exceedingly useful and not very expensive. There are various handy devices for moving such heavy material as draw-bars, journal boxes, car wheels, and also the heavier tools such as jacks, many of which have been illustrated in the technical papers.

It is a rare thing to find a gang of car repairers fully equipped with the right kind of tools to do their work to the best advantage, as they almost always lack a sufficient number of jacks, air-boring machines, or even of wrenches or similar small tools, the first cost of which could be saved every day. The capacity of a car repair track which turns out more than eight or ten cars a day will be very largely increased by furnishing a few woodworking machines, with the necessary power to operate them, the most essential being a rip-saw, cross-cut saw, and boring and mortising machine. There is an instance on record where such tools were furnished to a repair gang turning out 50 to 75 cars a day, and the consequent increase in the output represented an addition of at least ten or fifteen men to the force, and also caused a reduction in the average time required per car for repairs.

A blacksmith fire near the repair track for straightening bent brake connections and other odd jobs will save a great deal of loss of time both to the car repairers and to the cars, unless the main blacksmith shop is very near the repair yard.

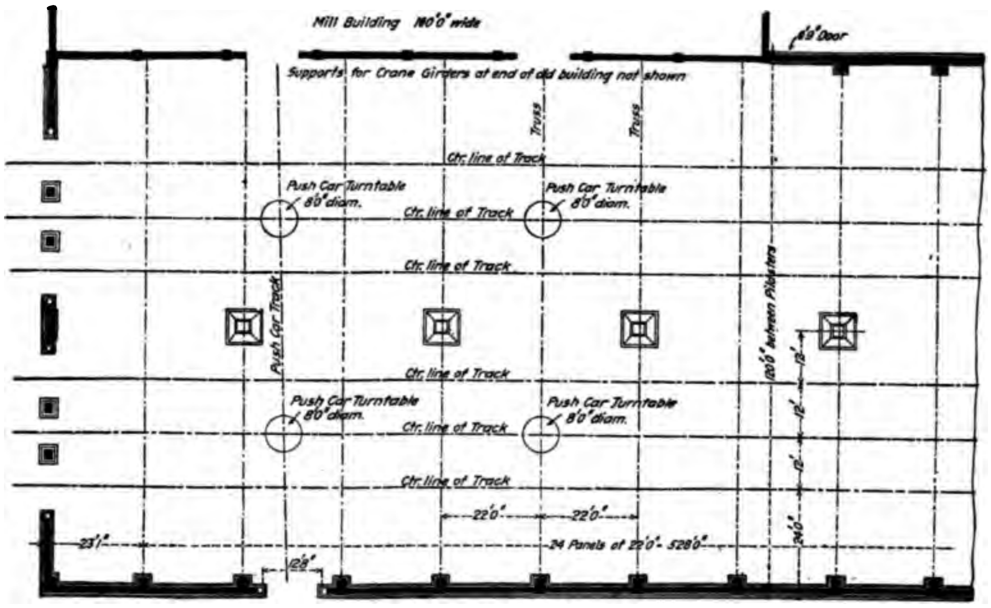
A sufficient supply of compressed air has come to be one of the most essential requisites for prompt car repair work, as it is generally used for boring, and frequently for jacking up cars.

The prompt switching of repair tracks and removing of finished cars and replacing them with bad-order cars is most important and should be done at such time as it will interfere least with the car repair gang.

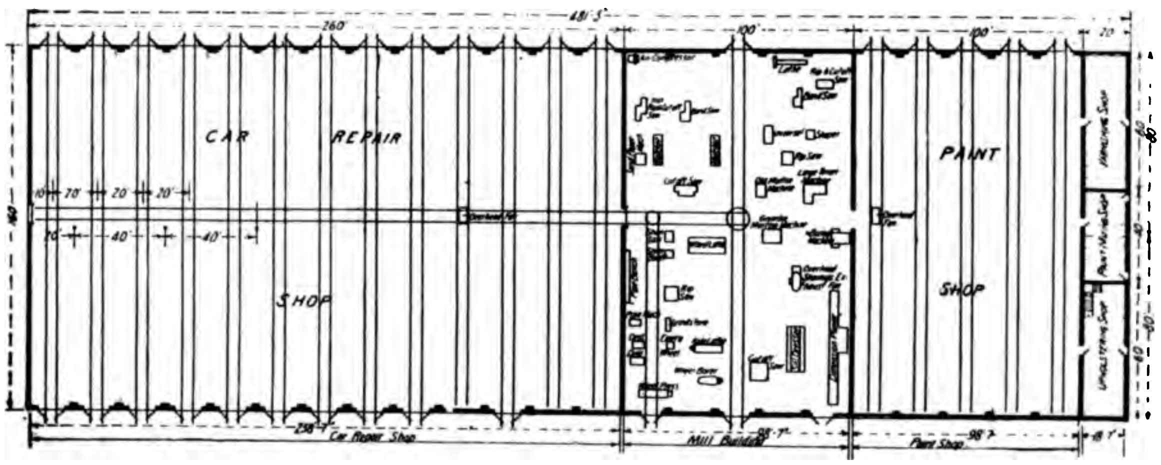
Freight repair sheds are generally furnished throughout the south for protecting car men from the sun, but are seldom seen in the north, where they would be fully as useful in protecting men from rain, snow and wind storms. There are many places where such sheds would enable men to work instead of going home during bad weather, and thereby shorten time cars are held for repairs.

A system of air pipes installed throughout freight repair and switching yards will save much loss of car service, besides insuring greater safety to trains on the road, but very few yards are so equipped.

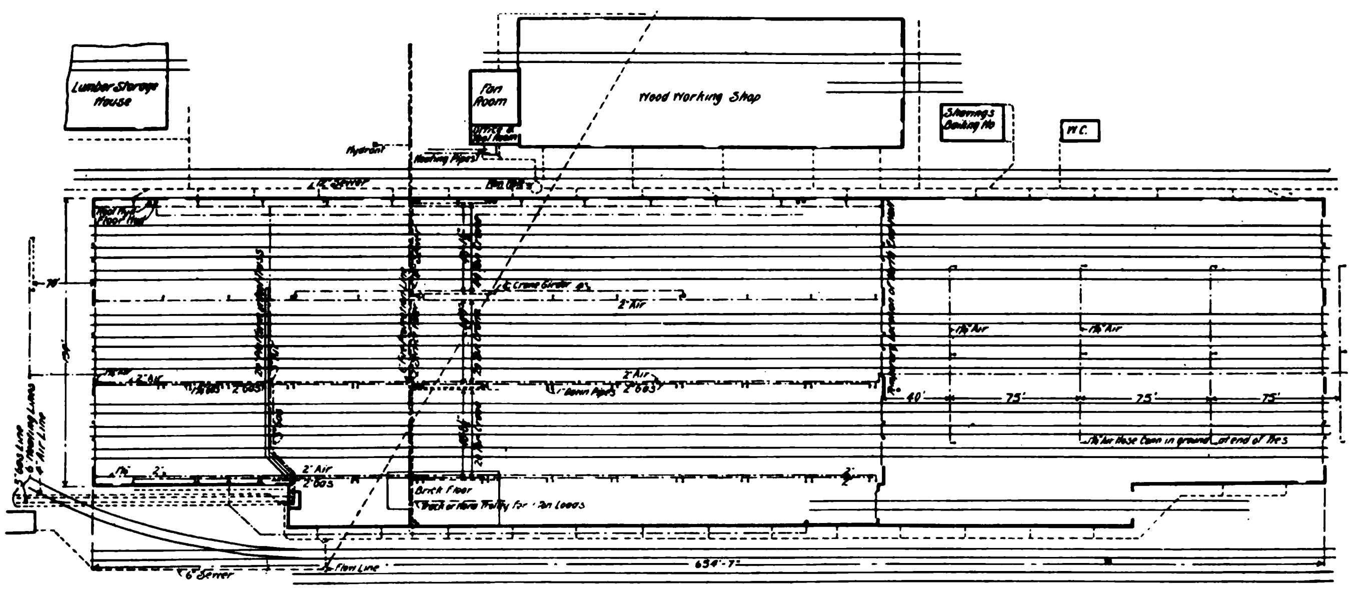
There are not many places on a railroad where a comparatively small expenditure will bring such large returns as in providing better facilities for freight car repair yards.



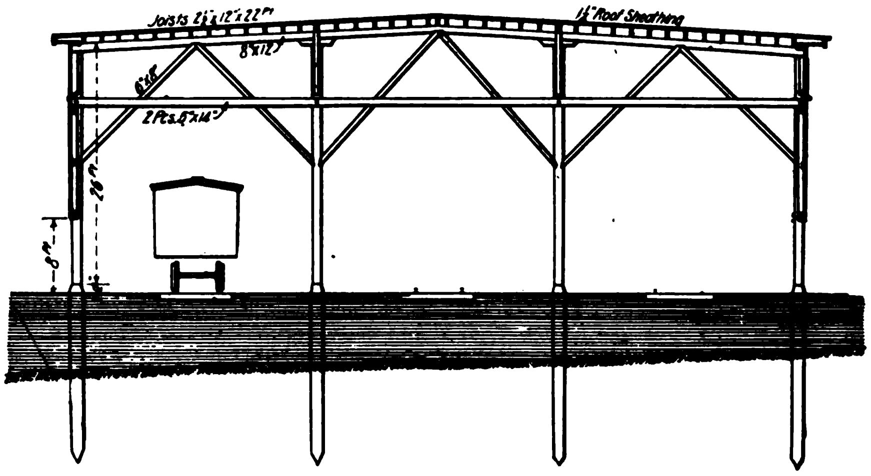
PARTIAL PLAN OF FREIGHT CAR SHOP AT BURNSIDE, ILL., I. C. R. R.



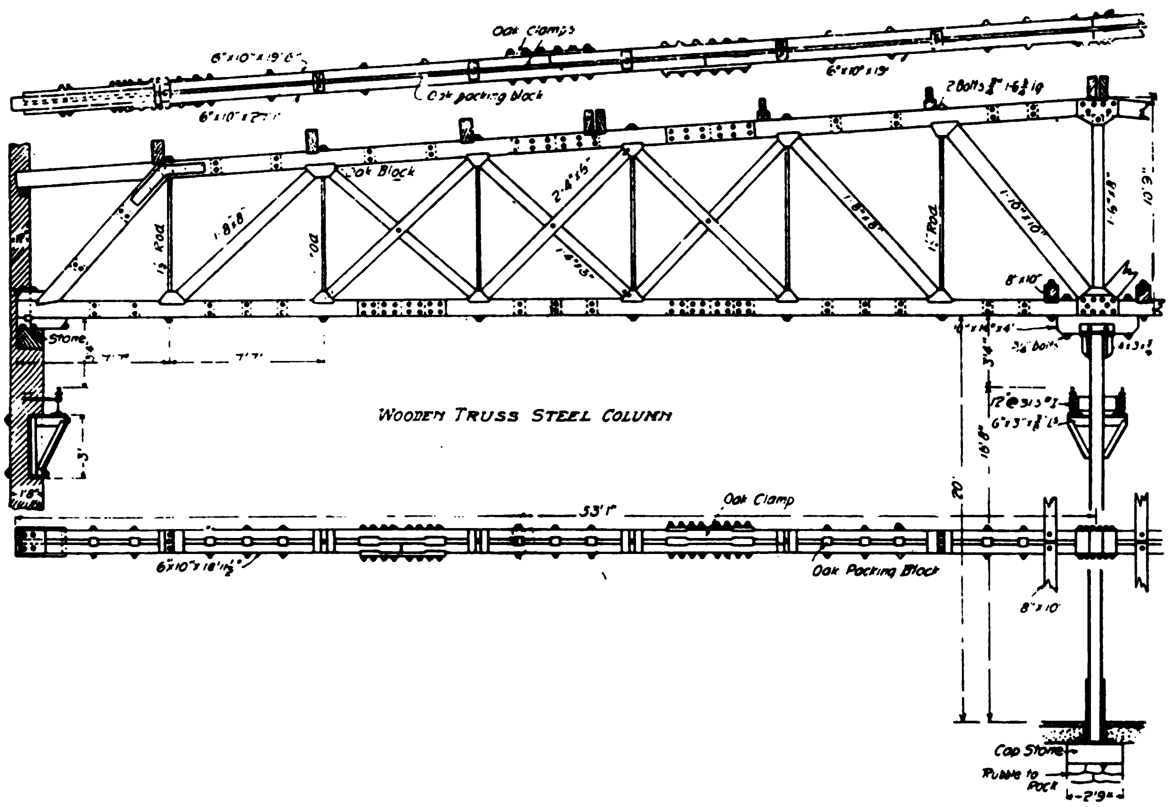
PLAN OF CAR REPAIR SHOP, PLANING MILL AND PAINT SHOP AT FOND DU LAC, WIS., WISCONSIN CENTRAL RY.



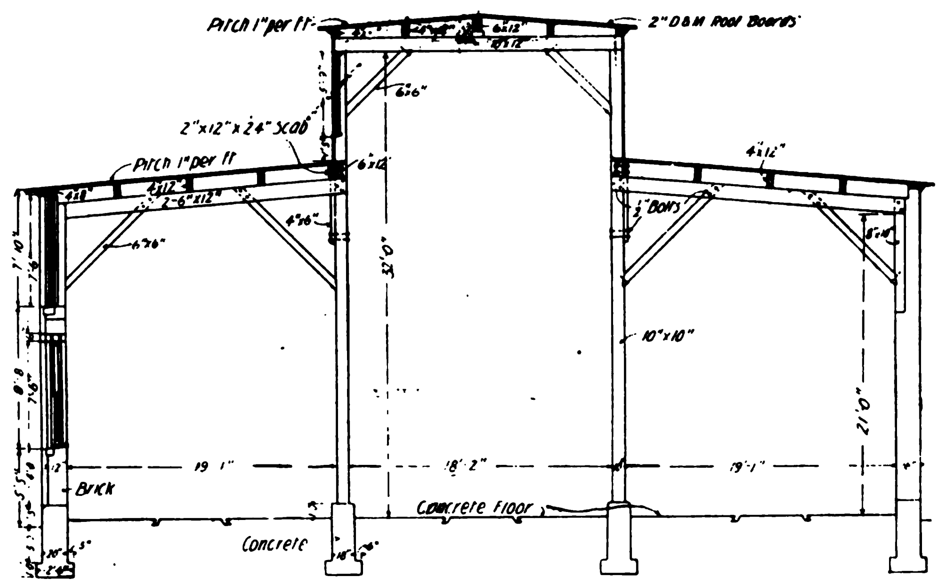
PLAN OF FREIGHT CAR SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.



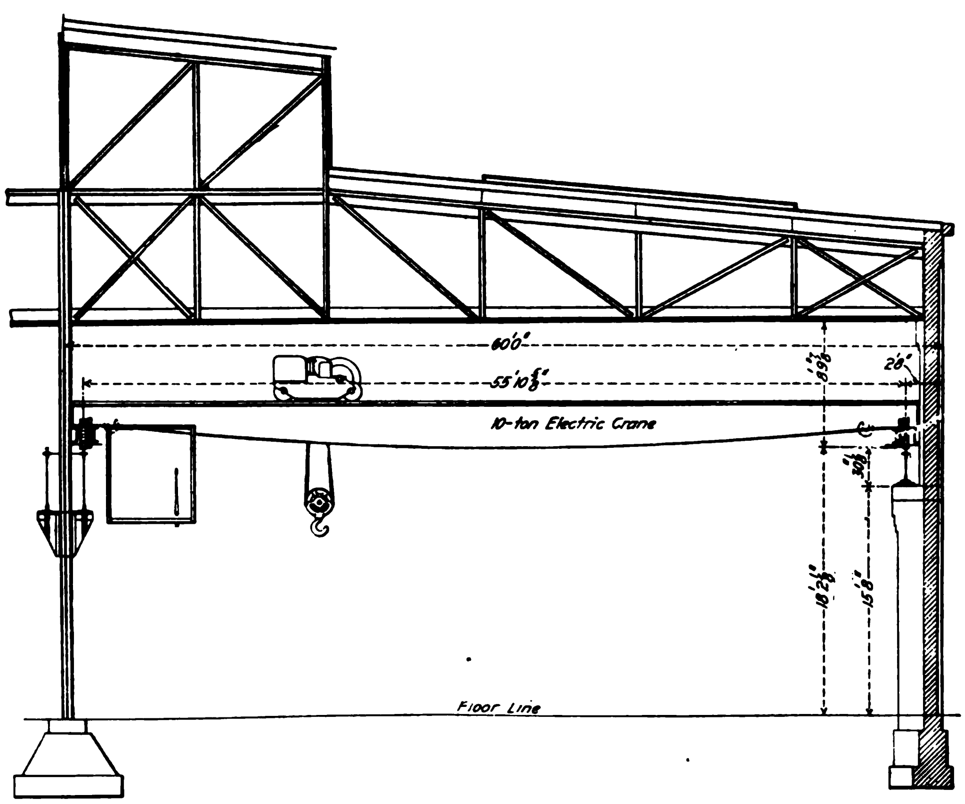
CROSS SECTION OF FREIGHT CAR REPAIR SHED AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



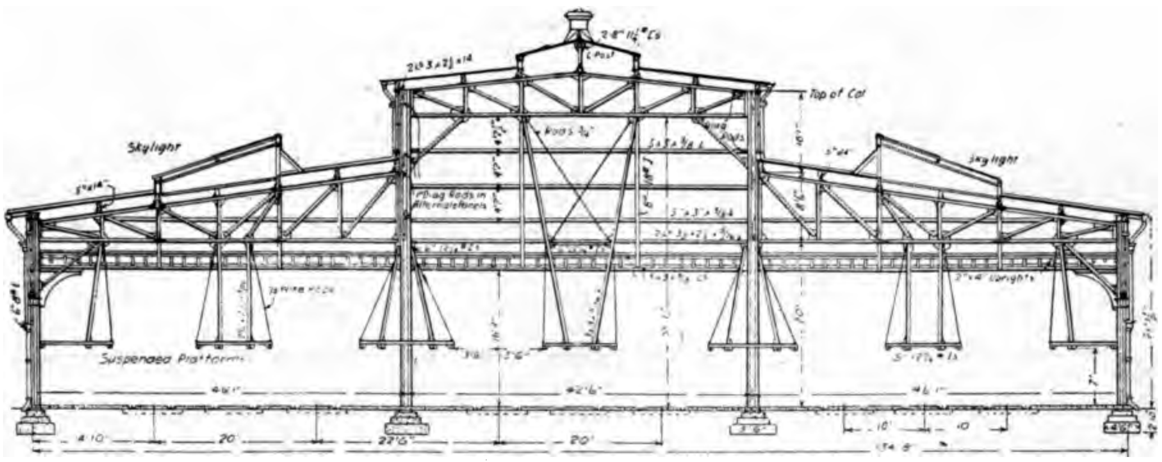
DETAILS OF CONSTRUCTION OF FREIGHT CAR SHOP AT ANGUS C. P. RY.



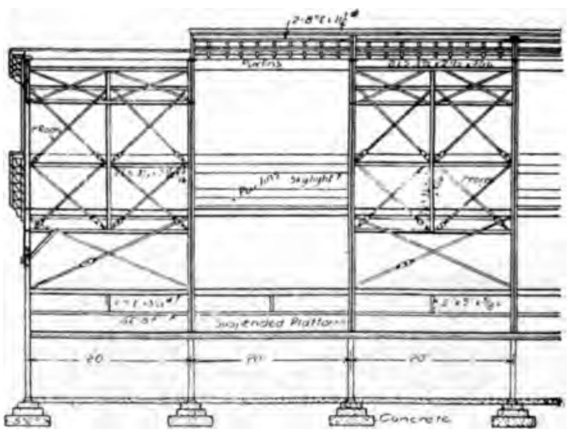
CROSS SECTION OF FREIGHT CAR PAINT SHOP AT SCRANTON, PA., D. L. & W. R. R.



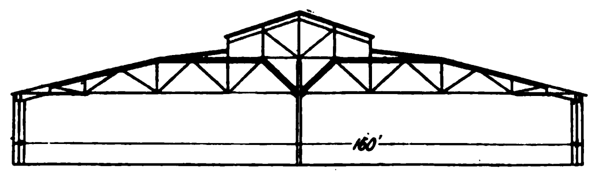
HALF CROSS SECTION OF FREIGHT CAR SHOP AT BURNSIDE, ILL., I. C. R. R.



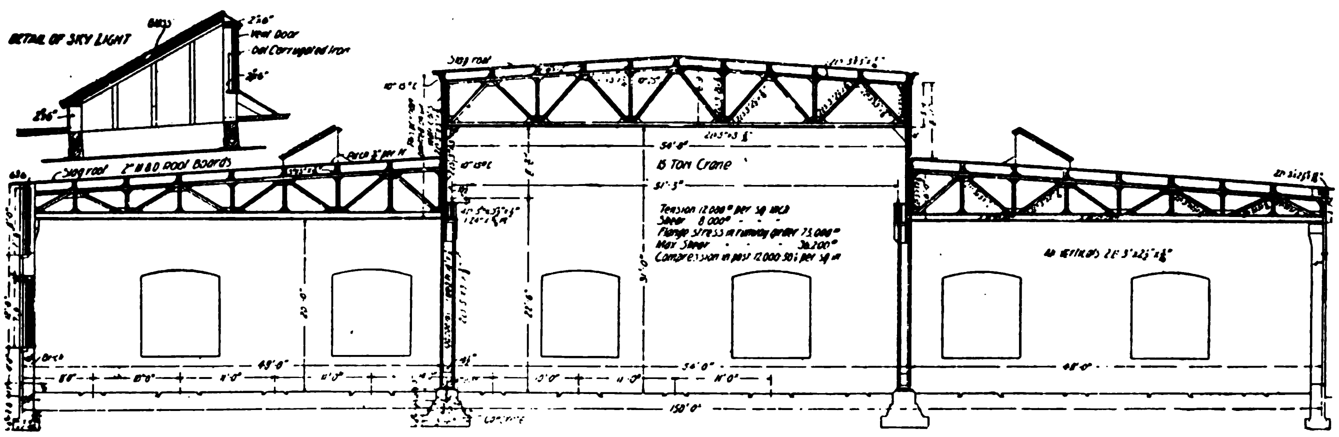
CROSS SECTION OF FREIGHT CAR BUILDING SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



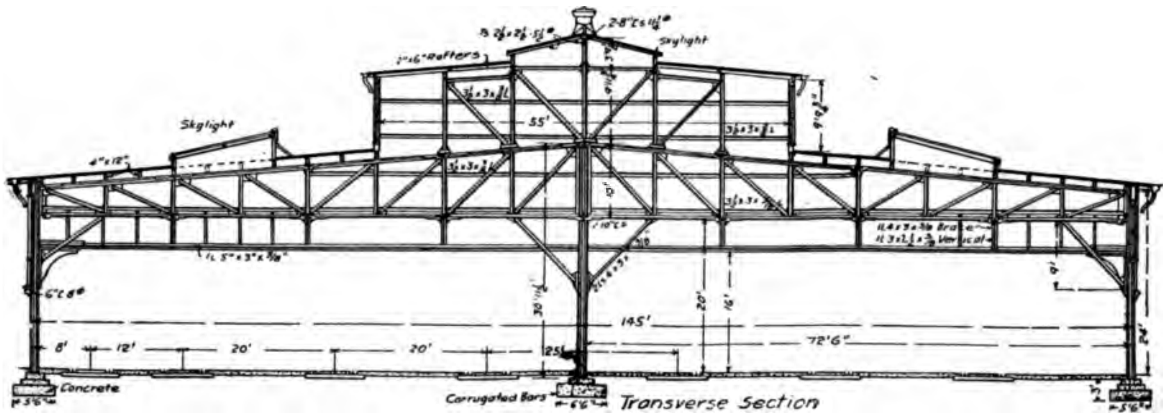
HALF LONGITUDINAL SECTION OF FREIGHT CAR BUILDING SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



SECTION OF FREIGHT CAR SHOP AT FOND DU LAC, WIS., WISCONSIN CENTRAL RY.



CROSS SECTION OF FREIGHT CAR REPAIR SHOP AT SCRANTON, PA., D., L. & W. R. R.



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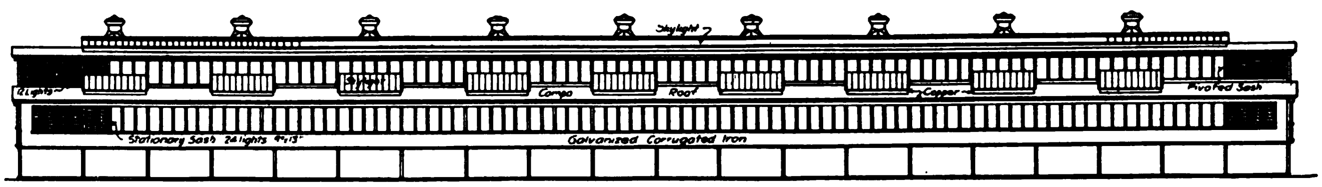
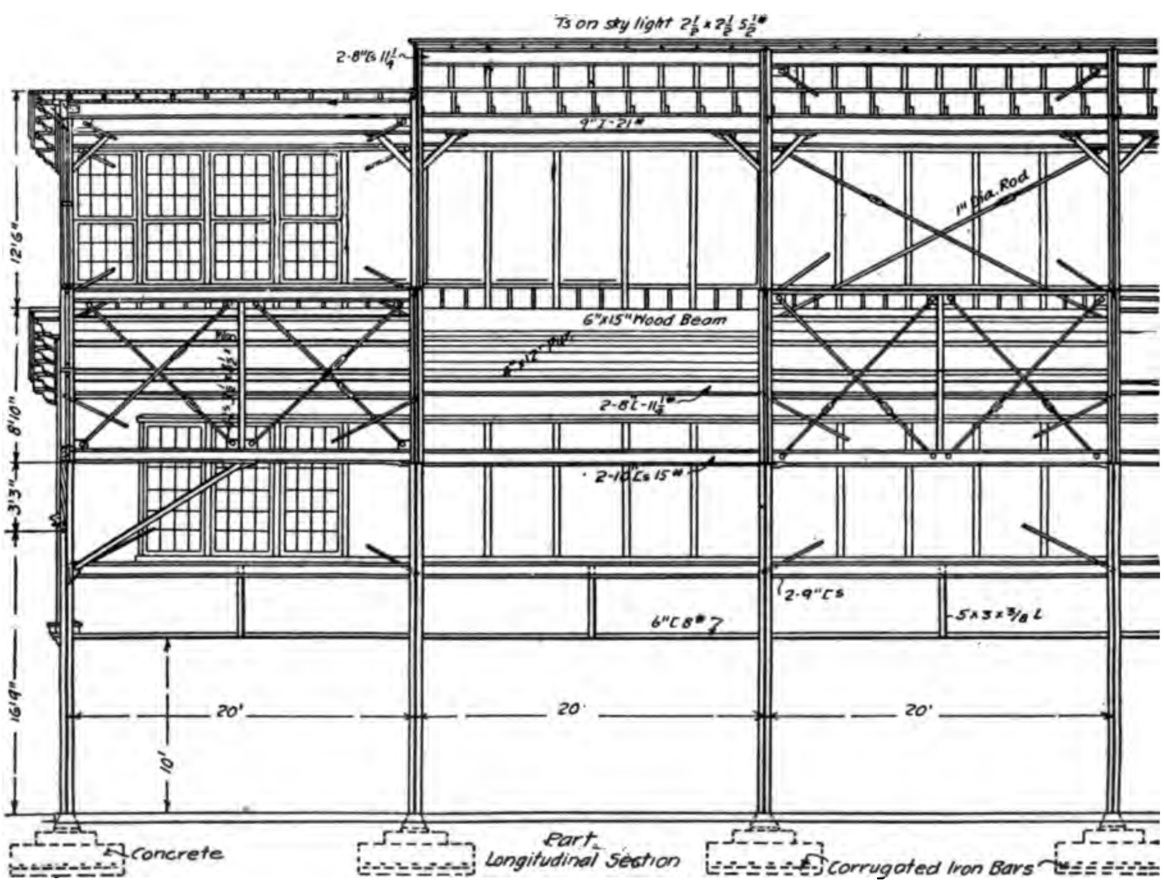
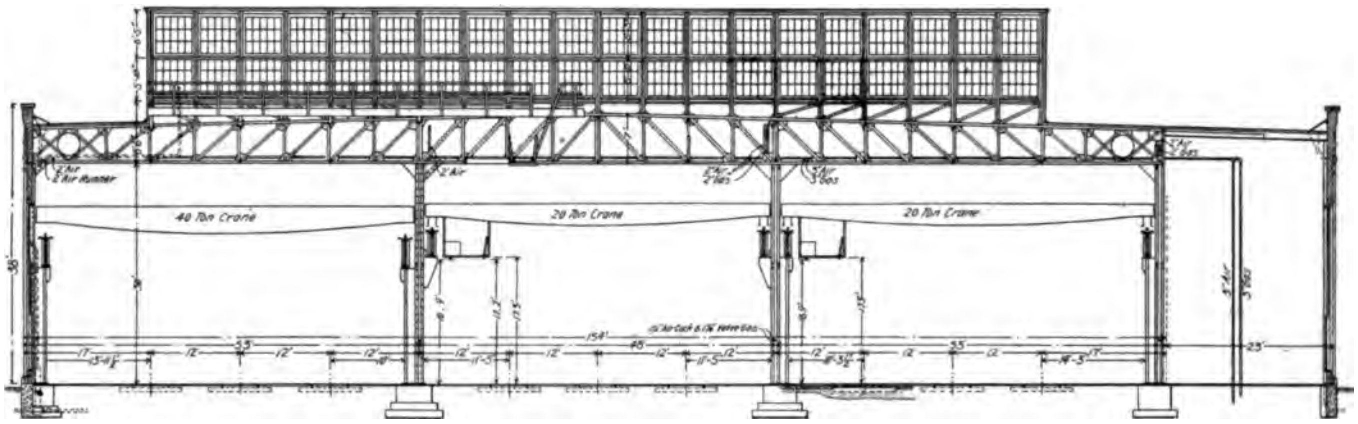


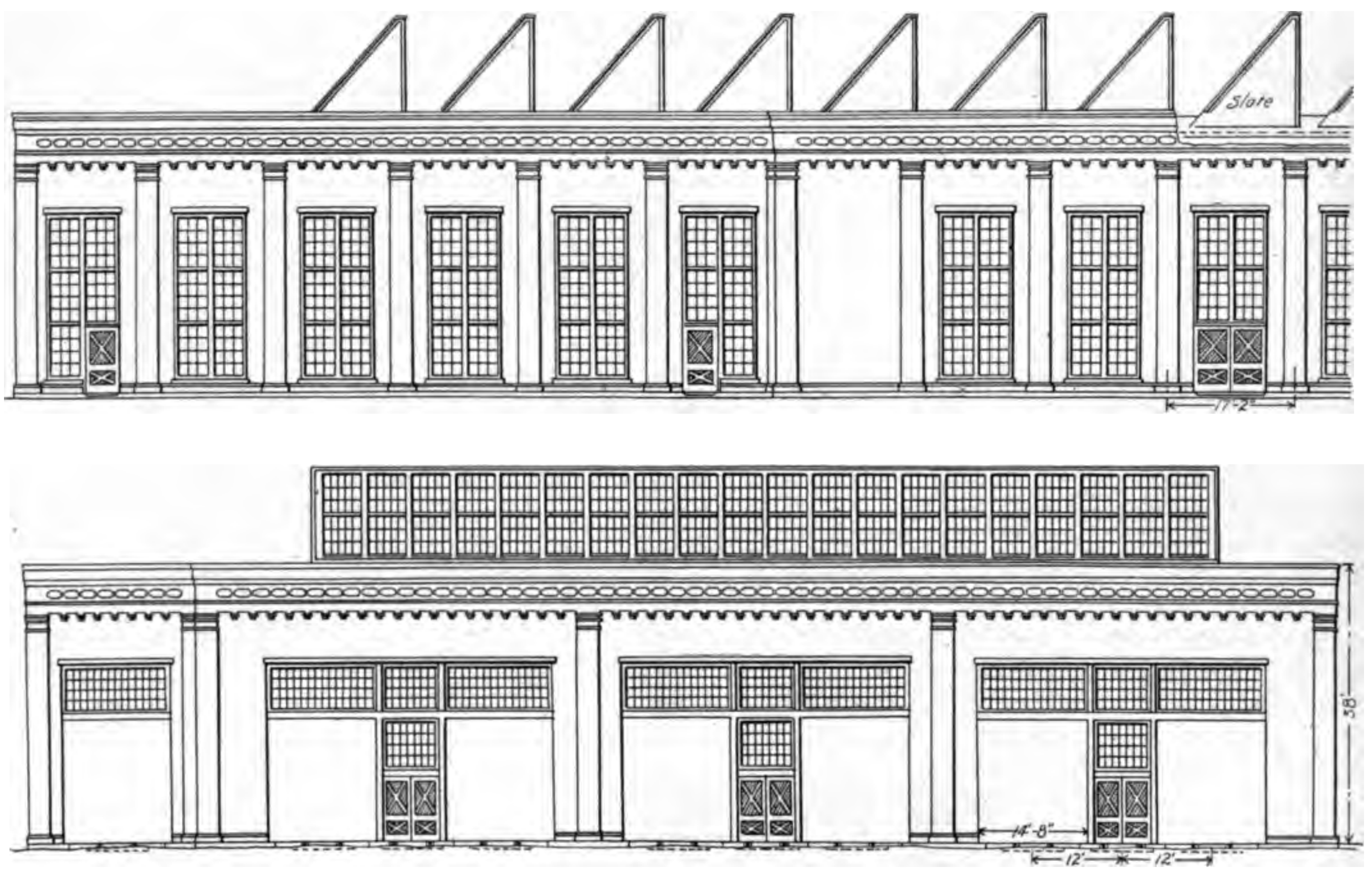
SIDE ELEVATION OF FREIGHT CAR REPAIR SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



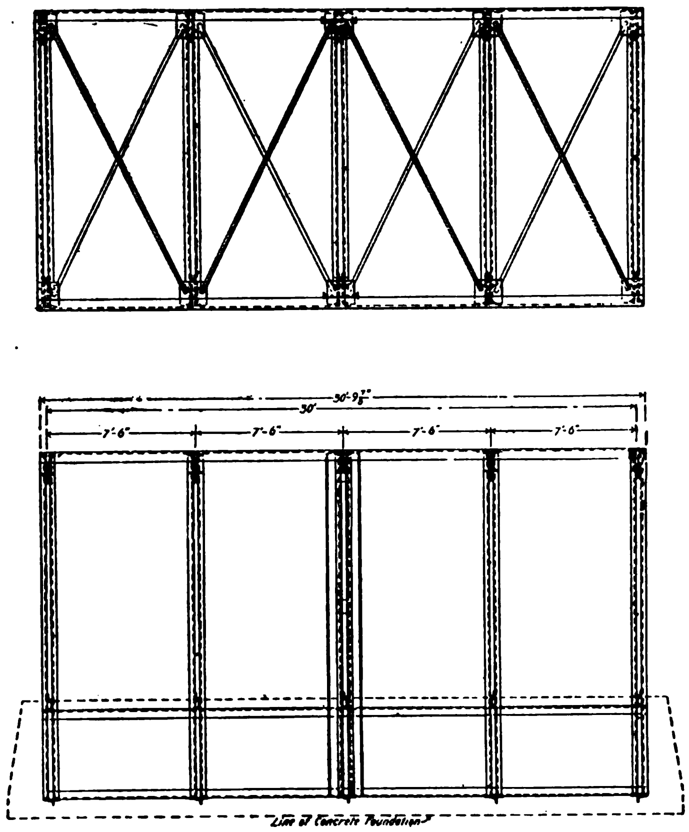
PARTIAL LONGITUDINAL SECTION OF FREIGHT CAR REPAIR SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



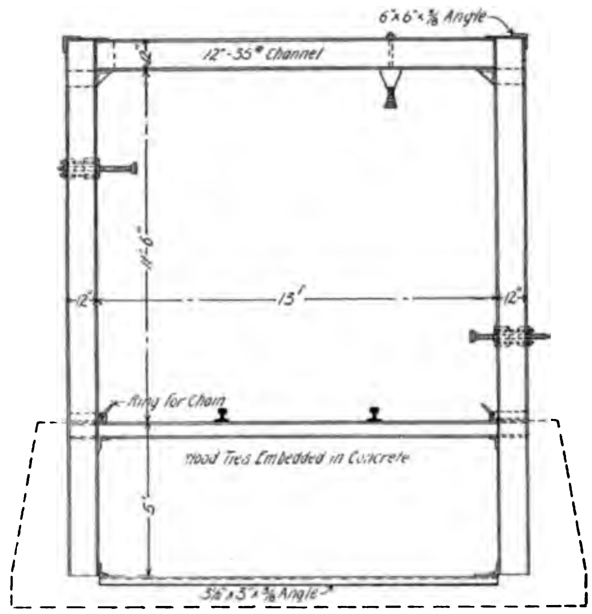
CROSS SECTION OF FREIGHT CAR REPAIR SHOP AT MCKEES ROCKS, PA., P. & L. E. R. R.



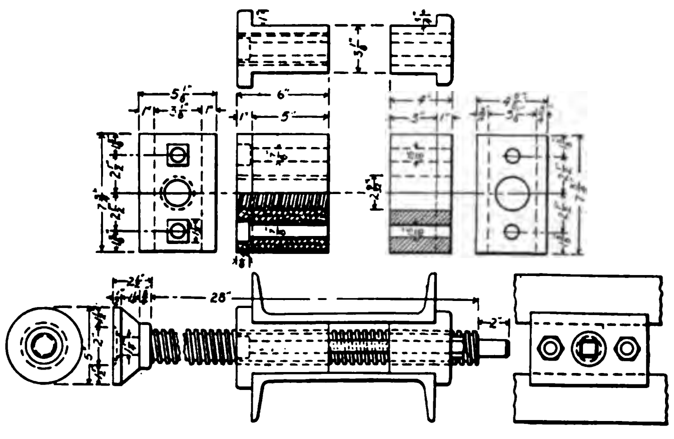
PARTIAL SIDE AND END ELEVATION OF FREIGHT CAR REPAIR SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.



PLAN AND SIDE ELEVATION OF STEEL CAR REPAIR FRAME IN FREIGHT CAR REPAIR SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.



END ELEVATION OF STEEL CAR REPAIR FRAME IN FREIGHT CAR REPAIR SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.



SIDE AND END ELEVATIONS OF SCREW JACK USED WITH STEEL CAR REPAIR FRAME IN FREIGHT CAR SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.

Railway Shop Up To Date

Chapter VII

PASSENGER COACH AND PAINT SHOPS

IN considering the passenger car department, the paint and coach shops should be treated collectively. The nature of the work on passenger cars and the effect of dust and dirt on the finished surfaces requires that construction and painting should be done in different shop buildings. The class of work required and the length of time that a passenger car is held in the shop during repairs or the time consumed in construction, demands that cars and workmen must be thoroughly and carefully housed.

Passenger equipment is usually put through the shop once in twelve to fifteen months and as traffic is heaviest during three months of the year and requires practically all available equipment, it is considered on many roads that there are but nine months left for passenger car repair work.

To keep the men employed during the slack season and to provide an equilibrium of forces, it is not unusual for a certain amount of building to be done at car repair shops. The layout of the average passenger car repair shop is equally suitable for new car construction and there is information at hand of a passenger car department built for repair work having been operated for the construction of new cars during several years.

LOCATION.

Except at those shops where all principal departments are served by a single transfer table, there is a decided tendency to place the passenger car department in an isolated location where the transfer table pit will offer the least impediment to general yard traffic. At several shop plants of recent construction, maintaining both locomotive and car departments, the transfer table of the passenger car department is the only one on the property. Where the principal departments are grouped around a single transfer table, the coach repair and paint shops are usually on the same side of the transfer table pit, placing the buildings of the car department as compactly as possible. Where the passenger shops are served by an individual table the prevailing practice is to locate the coach and paint shops on opposite sides of the transfer table pit, in parallel buildings, with the table operating between them.

BUILDING.

The principal details of the coach and paint shop are very similar. Both shops require ample natural light to be admitted through the roof as well as through windows in the walls, and to be so diffused as to light the space between the tracks rather than immediately over them.

Modern passenger car shops have brick walls with large window area. Wooden roof trusses and supports, as well as steel, have been used in the construction in some of the most prominent shops. At Readville and at Angus the roof trusses and supporting columns are of wood and at Collinwood they are of steel.

Examination of the dimensions of a number of prominent shops shows that a width of 90 feet is provided for several shops having a standing capacity of one car per track; 100 feet for a number of others having the same capacity per track and the Readville shop, where three cars are stood per track, is 225 feet wide.

A clear height of 20 feet from floor to lower chord of roof truss is considered suitable in both the coach and paint shops. At some prominent shops this height is 19 feet and sometimes a few inches higher.

NATURAL LIGHTING.

A number of paint shops have saw tooth roofs and this type is considered particularly well adapted for the requirements of the paint shop. For the most satisfactory diffusion of light between the cars saw tooth skylights are arranged transversely with the tracks.

The provision of liberal natural lighting at Collinwood is worthy of special attention. The total amount of glass in the side and end walls of the buildings equals 45 per cent of the total wall area. The total glass area in both roofs and walls equals 75 per cent of the total floor area. In the roof of the paint shop is a skylight 42 feet 4 inches wide by 245 feet long in the monitor and to this is added 34 separate skylights 21 feet by 11 feet. This gives an area of glass equal to 38 per cent of the projected area of the roof. The coach shop has a skylight 22 feet 4 inches wide by 335 feet long, extending the full length of the building and also 32 separate skylights, making 33 per cent of the projected area of the roof.

In both the paint and coach shops at Angus there is a transverse skylight in the roof above each space between working tracks. There are 27 skylights in each shop and each skylight is 49 feet long by 12 feet wide.

ARRANGEMENT OF WORKING TRACKS.

The most satisfactory arrangement of working tracks for the repair and construction of passenger equipment seems to have been decided beyond question and is well exemplified by the large number of shops now in operation, both old and new. This provides for standing cars on transverse tracks, or working spaces, and as access by a system of ladder tracks would be uneconomical of ground space and as passenger equipment cannot be handled to advantage with traveling cranes, the transfer table is the most suitable means of access to the passenger car shop.

It does not seem possible to formulate a definite rule by which to determine the size of shop or number of working tracks in accordance with the number of cars owned by the road. In general it may be said that the

average working space required by each car standing in the shop is about 270 square feet. A consideration of the most likely examples of passenger car shops would lead to the conclusion that a suitable spacing for working tracks provides a distance of 20 feet between centers in the coach shop. At most places the same distance between tracks prevails in the paint as in the coach shop. However, at Collinwood on the Lake Shore & Michigan Southern Railway and at Burnside on the Illinois Central Railroad, the tracks in the paint shop are spaced 18 feet between centers while those in the coach shop are spaced on 20-foot centers. It is thought by some that a spacing of 18 feet in the paint shop is sufficient in all cases. At the Angus shops of the Canadian Pacific Railway and at the Readville shops of the New York, New Haven & Hartford Railway, the tracks in the coach shop are spaced 24 feet between centers. At the former this is probably due to the fact that the shop was planned largely for the construction of new cars and it was thought advisable to provide greater working space between tracks. At Readville the shop is unusually wide and the roof trusses are supported by columns located between the working tracks and the additional space is provided on this account. The length of the shop, then, is determined by the number of working tracks it is desired to provide.

A shop of such width as to house but a single car on each working track has the advantage of providing freedom of movement of each car in the shop as it is completed. On this basis many shops have been constructed to stand but one car per track. This practice does not prevail in all cases, however. The Burnside shop of the Illinois Central Railroad stands two cars on each working track and at Readville, on the New York, New Haven & Hartford, three cars are placed on each track. Such an arrangement requires greater care in the operation of the shop to prevent a finished car from being obstructed by others not so far advanced in the stages of repair.

TRANSFER TABLE SERVICE.

Arguments have been presented in favor of serving a passenger car shop with more than one transfer table, where each track has a standing capacity of two or more cars. Such an arrangement would remove the objection to the longer working tracks; but would have the disadvantage of taking up valuable space with the additional transfer table, besides the additional first cost of the table and the expense of maintenance.

At Topeka, on the Atchison, Topeka & Santa Fe Railway, the present coach and paint shops are served by two transfer tables and a new paint shop now under consideration is to be served by a third transfer table. Each working track stands but a single car and the present second transfer table is probably provided for delivery between the planing mill, storage yard and truck shop and the coach shop.

The length of the transfer table pit naturally depends upon the length of the shop, and the width of the pit is governed by the length of table necessary to accommodate the longest cars of the road. While the passenger car department of three prominent shops are served by tables operating in pits 80 feet in width, 75 feet seems ample for present day requirements and this width prevails at many recently constructed shops.

The distance from the transfer table pit to each shop varies materially and prevailing practice has not established a precedent in this particular. At some shops the distance on both sides of the pit are equal and at others there is a greater space on one side. At those shops at which the spaces between the transfer table pit and the buildings are unequal, the greater space is more often on the coach shop side. This condition does not prevail in all cases and no general practice seems to have been followed in this particular.

Unless sufficient space is provided to stand a car between the pit and one of the buildings, it would seem a waste of valuable ground to allow a greater space than that required for opening doors. It is now usual to provide for truck erecting and repair in a separate truck shop or on special tracks set aside for this work, so that the additional space between the pit and buildings is not required by truck repair work. If a space of this kind is provided and is not used it is apt to accumulate more or less scrap and junk or develop into a storage yard.

A space of one hundred feet on the paint shop side will allow for standing cars while being scrubbed and stripped and for storage while waiting to get into the shop. Where the coach shop stands three cars per working track, as at Readville, it permits clearing these tracks promptly without waiting for cars to be removed from the paint shop tracks.

At Angus, on the Canadian Pacific there is a space of 100 feet between the coach shop and the pit and this space is used for finishing cars as they are removed from the interior of the shop. Since being built this shop has been used principally for the construction of new cars, and the provision of this outdoor working space permits clearing the erecting tracks earlier and provides for a greater output by allowing work to be begun on a new car before the one formerly occupying the track has been entirely completed.

At the Southern Railway shops at Knoxville, Tenn., there is a space of 100 feet on each side of the transfer table pit, between the pit and the shop building. At the Long Island Railroad shops at Morris Park, there is a space 15 feet on each side of the pit.

OPERATION OF TRANSFER TABLE.

Electric power has been so generally adopted in railway shops that it is safe to say this is the only power considered for operating the transfer table, except, perhaps, at old shops where peculiar conditions will not permit. A single direct current motor of 50 horse power is capable of handling the heaviest car at a good speed. The speed of tables varies from a minimum speed of 100 feet per minute up to about 300 feet per minute when running light. The transfer table is usually equipped

with a winding drum by which cars are warped in and out of the shop.

Power is delivered to the table motors by various means. In some instances it is delivered by trolley wires carried on poles along one side of the pit; in others by wires suspended above the center of the pit, and sometimes the wires are secured to the stringers carrying the track rails.

FLOOR.

Floors of coach shops are of wood and of concrete. Floors of paint shops are usually of concrete and so sloped as to lead toward a gutter to drain the water dripping from cars while cleaning. The most suitable arrangement is a gutter running the full length of each space between tracks and covered with an iron grating. At Kingsland, on the D., L. & W., the coach shop has a level floor of concrete. The paint shop has a vitrified brick floor laid on concrete, the brick work being arched for drainage. The wooden floor absorbs moisture and has a tendency to keep the interior of the shop damp. It is said that on this account varnish will dry nearly a day quicker where the car is standing over a concrete floor than when the floor is of wood.

TRUCK REPAIRS.

While some shop plants provide a small shop building for the repair and erection of trucks, others provide two or more tracks at one end of the coach shop for this purpose. In the more prominent shops these tracks are served by hoists to facilitate the work and, while not always used, air hoists are considered very suitable. In the coach shop of the D., L. & W. at Kingsland, two tracks in one end of the building are reserved for truck work and are served by a 15-ton crane.

FIRE PROTECTION.

At several coach and paint shops the buildings are divided into sections by fire walls to prevent the rapid spread of flames in case of a conflagration. Such walls include doors wide enough to provide for trucking and other traffic and the opening is usually about 6 feet. These doors are usually kept open at all times, but have an automatic feature in their hanging that insures certain action in case of fire. They are hung on an inclined track and held open by means of counterweights which are released and allow the doors to close by gravity upon a rise of temperature sufficient to melt a fuse which controls the weights.

SCAFFOLDS.

There are many different types of scaffolds in use, as a number of prominent shops have worked out designs adapted to existing conditions. Adjustable scaffolds are now generally used and are far superior to the stationary scaffold or the old-time method of using trestles and plank.

PAINT MANUFACTURE.

The manufacture of paint is carried on more extensively by the Chicago & Northwestern Railway than by any other railway of which information is at hand. Deposits of ore occur near the line of the Chicago & Northwestern, so that the ore is obtained at a very reasonable cost. Ore is mined by the company, delivered to the paint manufacturing department of the company's shop at Chicago and the entire process of paint manufacture, from mining the ore to painting cars and locomotives, is conducted by the company.

Many other railway companies have paint mixing and grinding machines as part of the paint shop equipment; but it is not usual for paint manufacture to be carried on to any great extent by the railways.

PAINT SHOP AT MCKEES ROCKS—P. & L. E. R. R.

The paint shop of the Pittsburg & Lake Erie Railroad is constructed according to a design peculiar to itself and is different from the more common design of shop for the same class of work. Due to the shape of the ground on which the McKees Rocks shops are built, the paint shop is situated in an isolated location. It includes a number of interesting features with regard to both design and facilities provided.

The building is 204 feet long by 85 feet wide, inside, with a clear height of 19 feet 3 inches from floor to roof truss. The roof is supported between walls by three rows of steel columns, of five columns each, dividing the shop into six sections. The section at the south end, 34 feet wide, is partitioned off to provide accommodations for the washing and varnishing departments, office, etc. The partitions are built of concrete 3 inches thick, on expanded metal, all of which are covered up to the roof. Natural day lighting is provided by saw tooth skylights traversing the entire width of the floor and having northern exposure.

Convenience for the workmen is provided for by a suitable arrangement of lavatories and closets in one corner of the workroom. The closets are located on an elevated platform or balcony 9 feet above the floor and the wash basins are situated beneath.

There are four longitudinal tracks in the shop spaced on 20 foot centers and each track has a standing capacity of 2 cars. The tracks are provided with working pits of concrete construction and the floor of the shop is of concrete.

COACH AND PAINT SHOP AT PORTSMOUTH, S. A. L.

As representative of a shop which may be constructed rapidly and at small cost as well as one suitable for a mild climate the coach and paint shop of the Seaboard Air Line at Portsmouth, Va., is worthy of attention. This shop was built to replace the passenger car repair facilities which had been destroyed by fire and the work of construction was begun so soon after the debris from the fire had been cleared away that there was not time to prepare elaborate plans and the building was erected from rough pencil drawings.

The building is 330 feet long by 80 feet wide, containing 16 repair tracks, placed on 20 foot centers and served by a transfer table operating in a pit 330 feet long by 70 feet wide. The building is of brick construction to the height of the bottom of the windows above

which a wooden frame is covered by corrugated galvanized iron. Between the doors are high windows extending from the brick wall almost to the roof, providing ample light and their location is such as to distribute the light between the working tracks.

In the roof is a monitor extending the entire length of the building with side window lights. The flooring is of cement between the tracks, the cement extending to a jacking beam on each side of the track and flush with the flooring; the space between the rails is left open above the cross ties, except at the end of the tracks near the doors, which is boarded over for trucking material up and down the shop. Gutters are provided on each side of each track in such a position as to be immediately under the eaves of the car, and these gutters are so sloped as to drain towards the transfer table pit. The roof is covered with five-ply tar paper, over which is spread a coating of tar and pebbles. The doors through which cars are taken into the building are of the rolling steel type and at the back of the building there are double swing iron sheathed doors, 8 feet high through which trucks are rolled to the tracks extending about 25 feet beyond the building on which truck repair work is done.

In the east end of the building a section within the monitor is floored over, and constitutes a room in which upholstery work is done. This is connected by a stairway with the first floor and a small elevator for delivering material.

The building is heated by a direct steam system, pipe radiatiors being arranged longitudinally between the posts and beneath work benches, which are supported by the posts, the arrangement being such that a radiator is located between each track.

Lockers for the use of the workmen are arranged along the end and one side of the building, and these include a set which are numbered to correspond to the several working tracks, each large enough to hold the brass trimmings, lamps, etc., from one car.

No separate department has been provided for paint work and all varnishing, etc., is done within the coach repair and paint shop. The only provision made against dust, while cars are being painted, is the systematic location of the cars as they are brought into the shop; by this method two or three cars are standing between those on which repair work is being done and those which are being varnished.

In order to gain space, four tracks on the side of the transfer table opposite to the shop building are used for stripping and trimming coaches so that by the time they are brought into the shop they have been thoroughly stripped and cleaned, thereby keeping the objectionable and dirty work outside of the shop.

The coach repair and paint shop is connected with the mill building by a board walk to facilitate the delivery of material.

HEATING SYSTEM IN PAINT SHOP AT MIDDLETOWN, N. Y., N. Y. O. & W. RY.

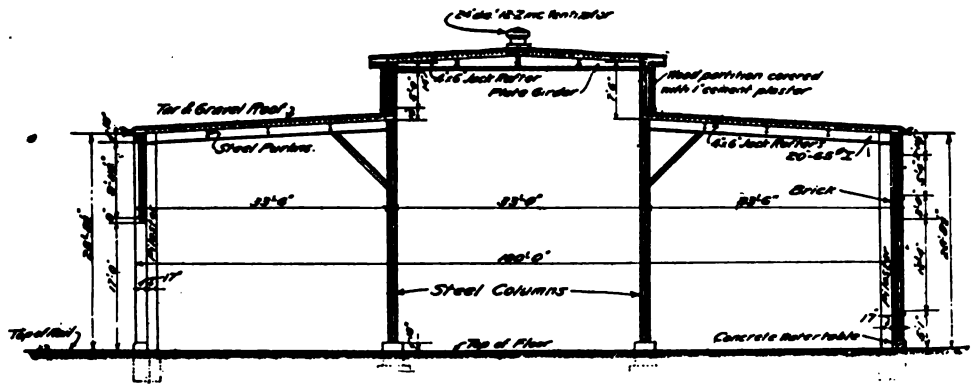
The arrangement of the delivery pipes of the heating system in the paint shop of the New York, Ontario & Western, at Middletown, N. Y., represents an innovation in paint shop heating. In more common arrangements of the blower system the air is distributed through overhead pipes extending across the roof and provided with long discharge pipes extending downward nearly to the floor. At Middletown the distributing pipes are carried beneath the floor.

The paint shop is a building with brick walls in which the roof structure is of wood and supported by two rows of wooden columns. The building as at present erected is 384 feet long, but designed for an addition of 80 feet. Its total width is 66 feet. There are three longitudinal working tracks arranged on 22 foot centers.

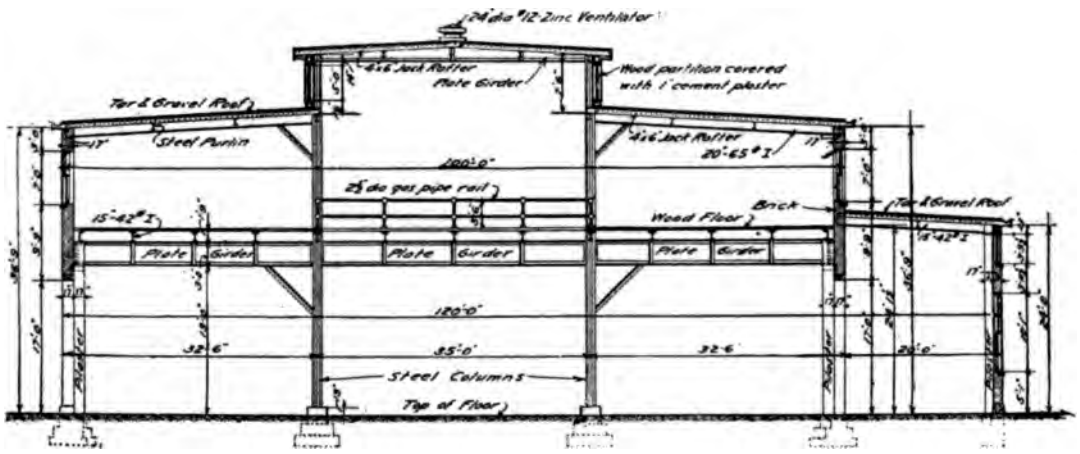
The heating equipment consists of an 8-foot fan wheel enclosed in steel plate casing connected with a casing of the same material containing the heater. In this heater are compactly arranged 10 sections containing 6,800 feet of 1-inch pipe, across which the air is drawn into the fan and thence discharged to the distributing system. The rapidity of air flow produced by the fan increases the efficiency of the heating surface from 300 to 500 per cent above that of the same area exposed in still air. A direct-connected 8 by 12-inch steam engine drives the fan up to a maximum speed of over 200 revolutions per minute, which is sufficient to insure a velocity of about 3,500 feet per minute through the discharge pipe. The heater is designed for the use of high pressure steam, and arranged so that the exhaust from the fan engine may be completely utilized.

The complete apparatus is placed in a small lean-to mid-length of the main building. Its central position reduces to a minimum the cost of the distributing system. Beneath the floor and alongside each of the walls and the column piers run four tile distributing pipes branching from the main brick cross duct from fan. Branches from these pipes lead to floor level, the upper portion of each being constructed of heavy galvanized iron, and so designed as to throw the escaping air at an angle to the floor. As a consequence, there is maintained at floor level a constantly changing volume of warm air which naturally ascends across the painted surfaces of the cars, thereby increasing the rate of drying. The constant replacement of the rising air by the incoming heated volumes insures a fresh warm atmosphere, which is particularly conducive to rapid drying.

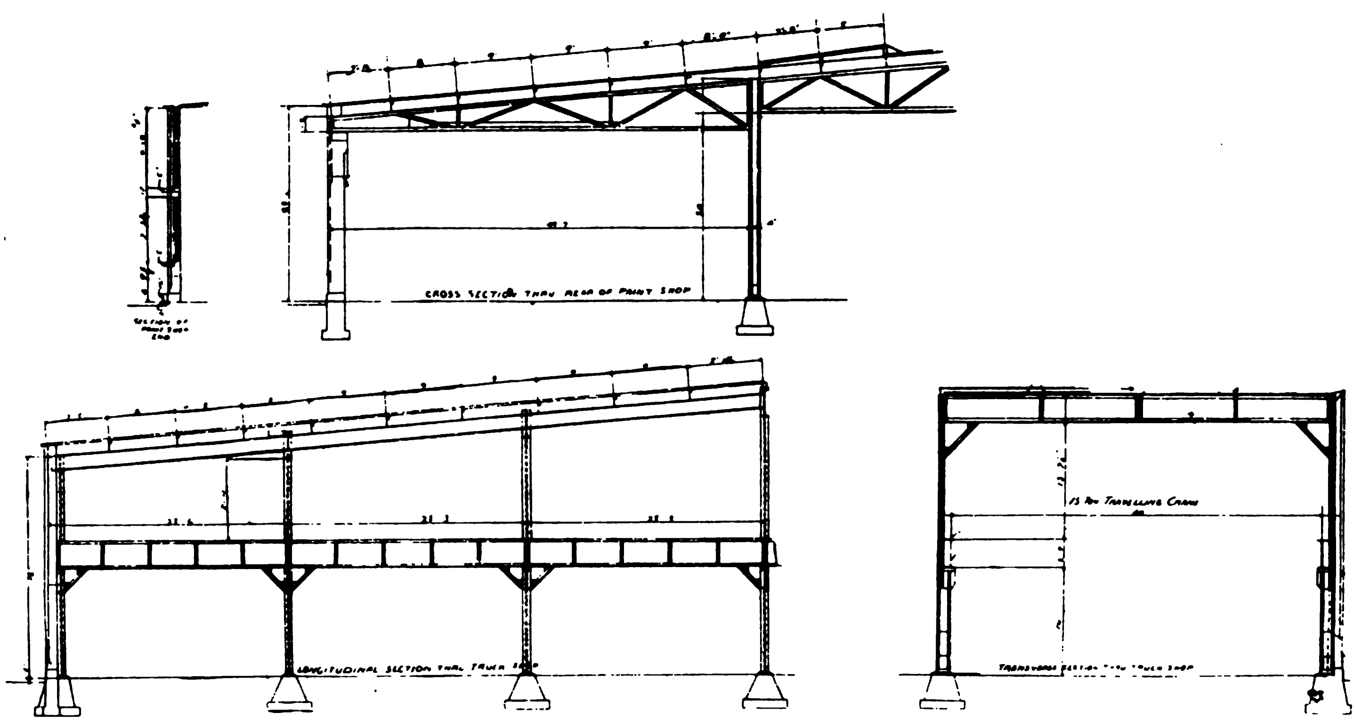
The outlets, which range from 6 inches to 8 inches in diameter, are spaced 16 feet apart so that practically perfect distribution and mixing is procured. Those in the middle of the building are protected from injury by the adjacent columns. The building is warm where warmth is desired—at the floor. The small rooms at the end of the building are heated by the same system through risers extending up from the underground ducts.



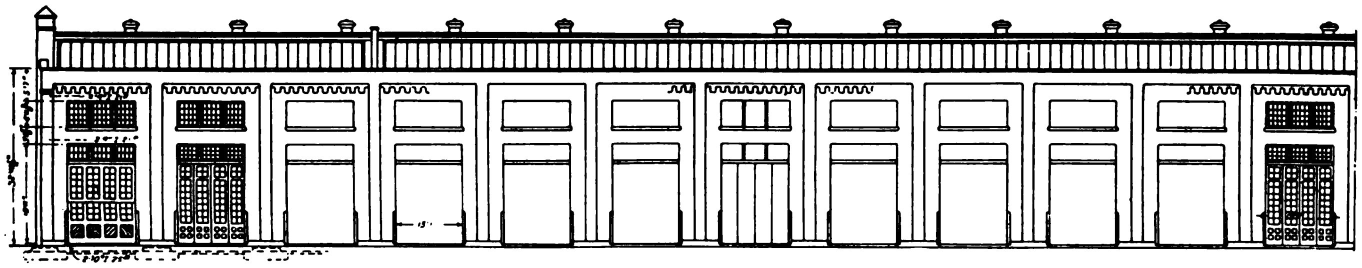
CROSS SECTION OF PAINT SHOP AT SEDALIA, MO., M. P. RY.



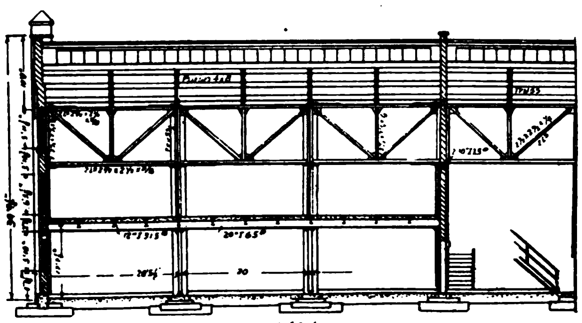
CROSS SECTION OF COACH SHOP AT SEDALIA, MO., M. P. RY.



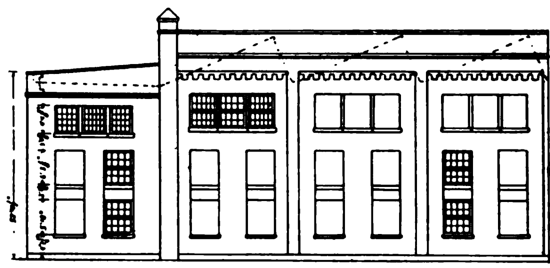
TYPICAL SECTIONS OF PASSENGER CAR SHOPS AT KINGSLAND, N. J., D. L. & W. R. R.



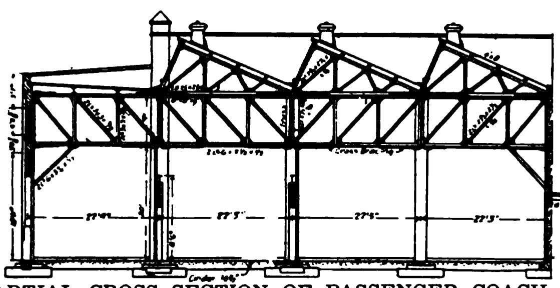
SIDE ELEVATION OF PASSENGER COACH AND PAINT SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



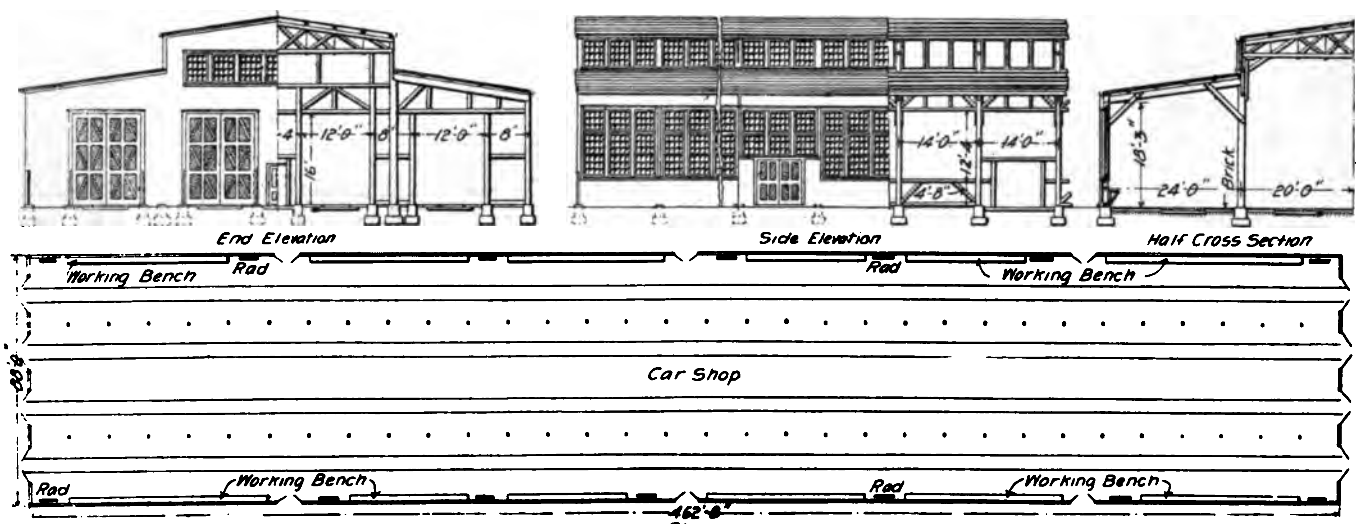
PARTIAL LONGITUDINAL SECTION OF PASSENGER COACH AND PAINT SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



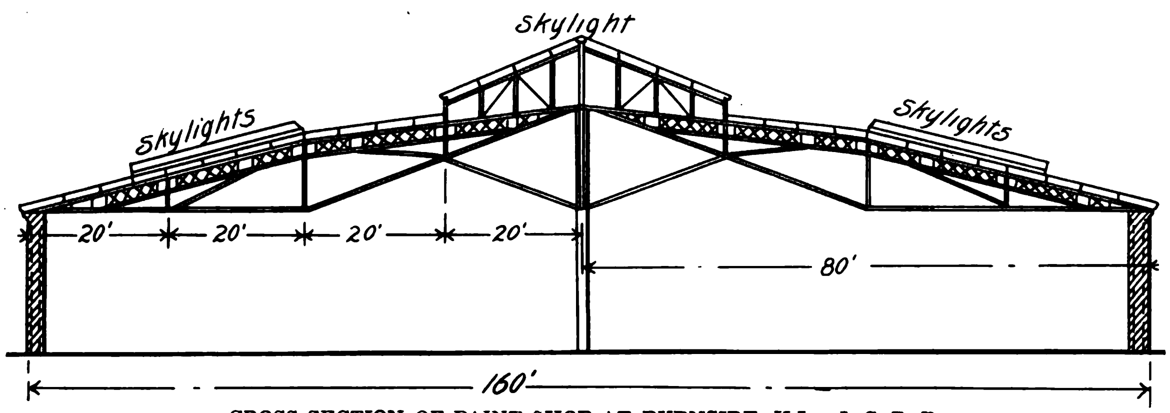
PARTIAL END ELEVATION OF PASSENGER COACH AND PAINT SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



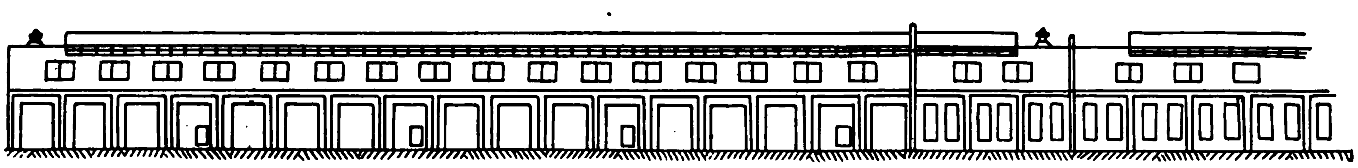
PARTIAL CROSS SECTION OF PASSENGER COACH AND PAINT SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



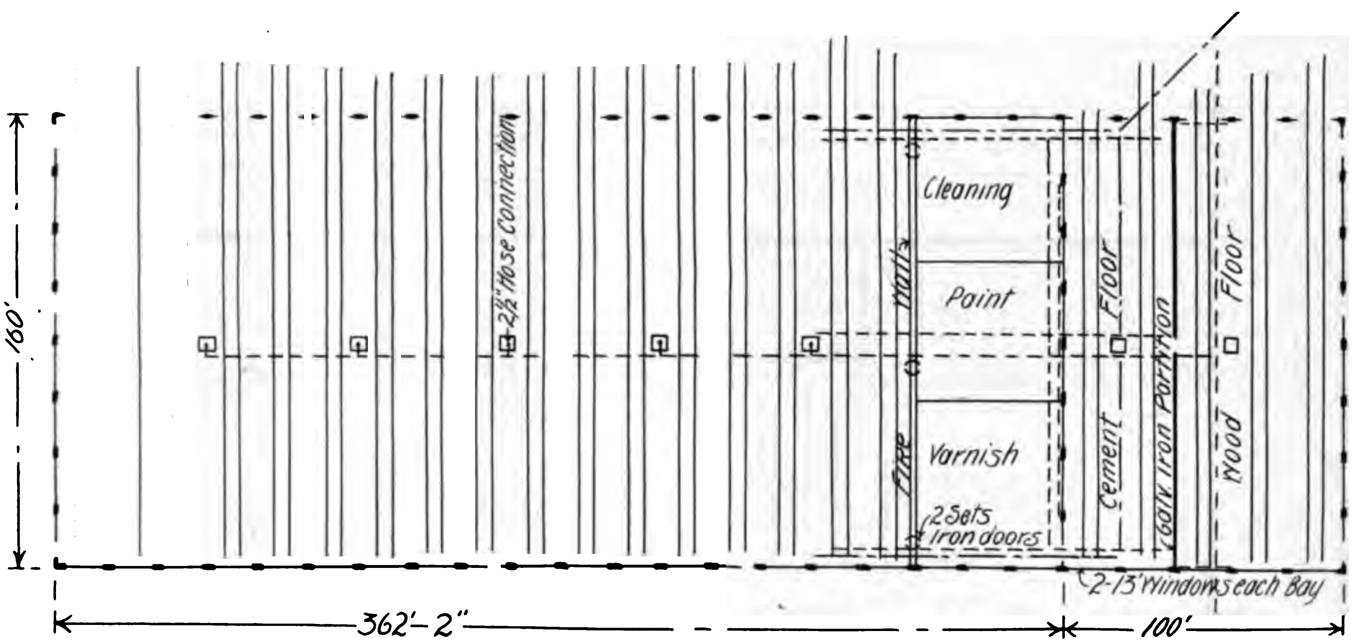
PLAN, ELEVATIONS AND SECTIONS OF PASSENGER COACH AND PAINT SHOP AT EAST DECATUR, ILL., WABASH R. R.



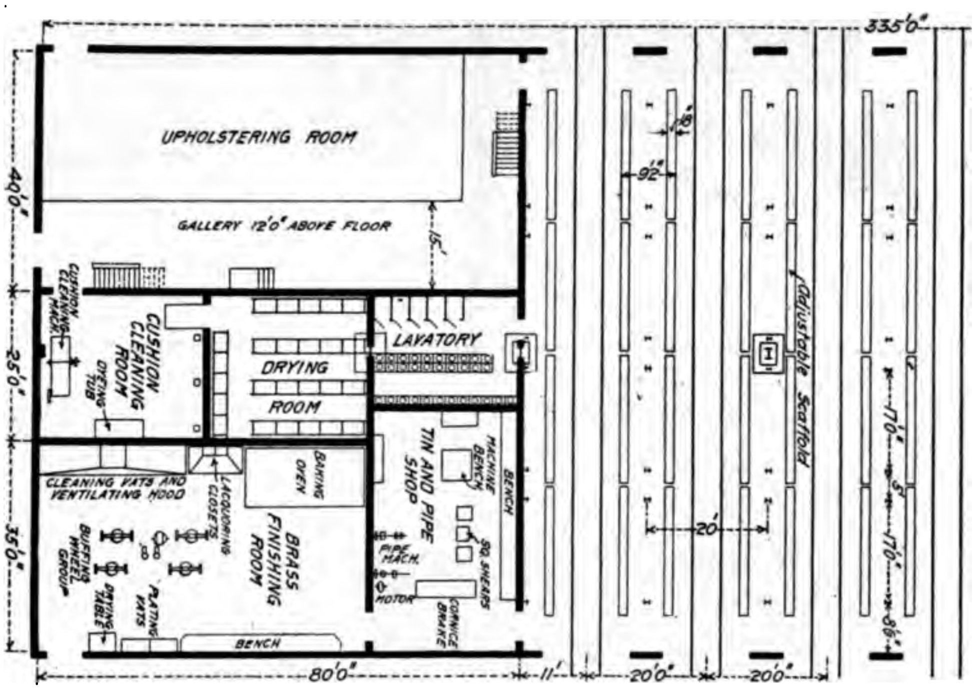
CROSS SECTION OF PAINT SHOP AT BURNSIDE, ILL., I. C. R R.



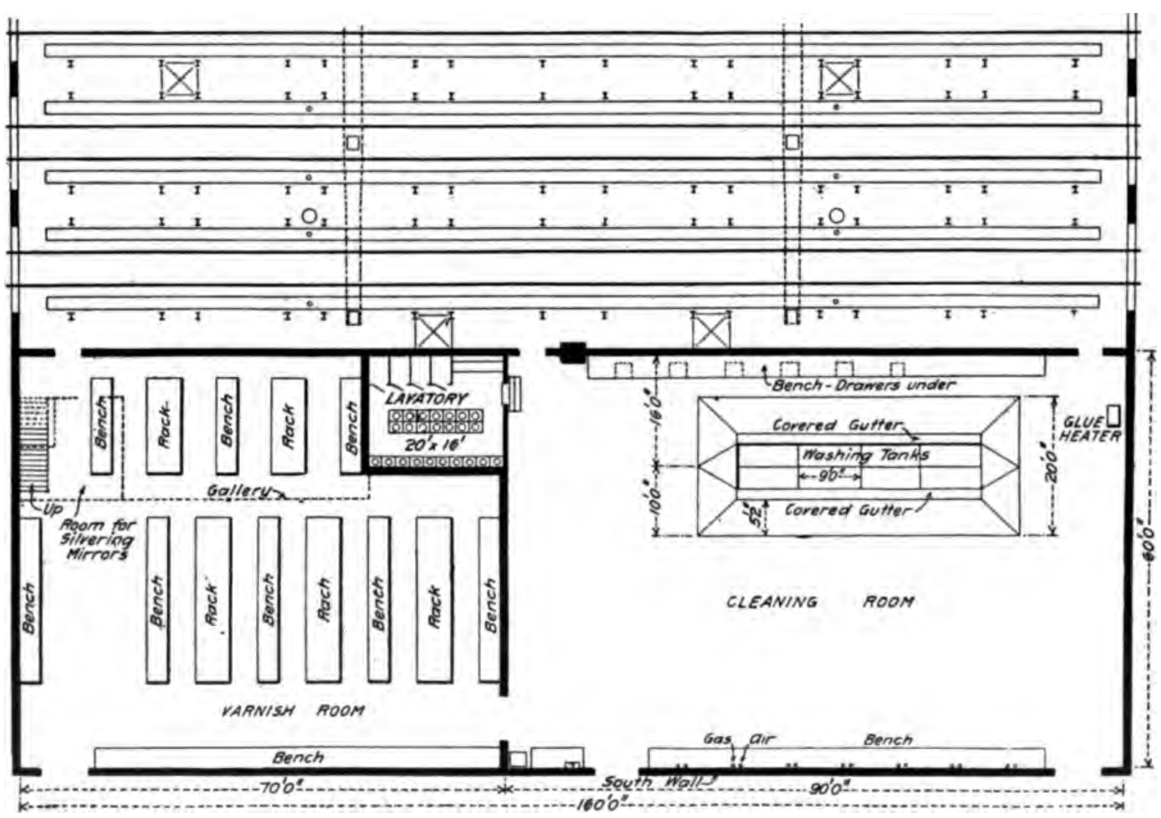
SIDE ELEVATION OF PAINT SHOP AT BURNSIDE, ILL., I. C. R. R.



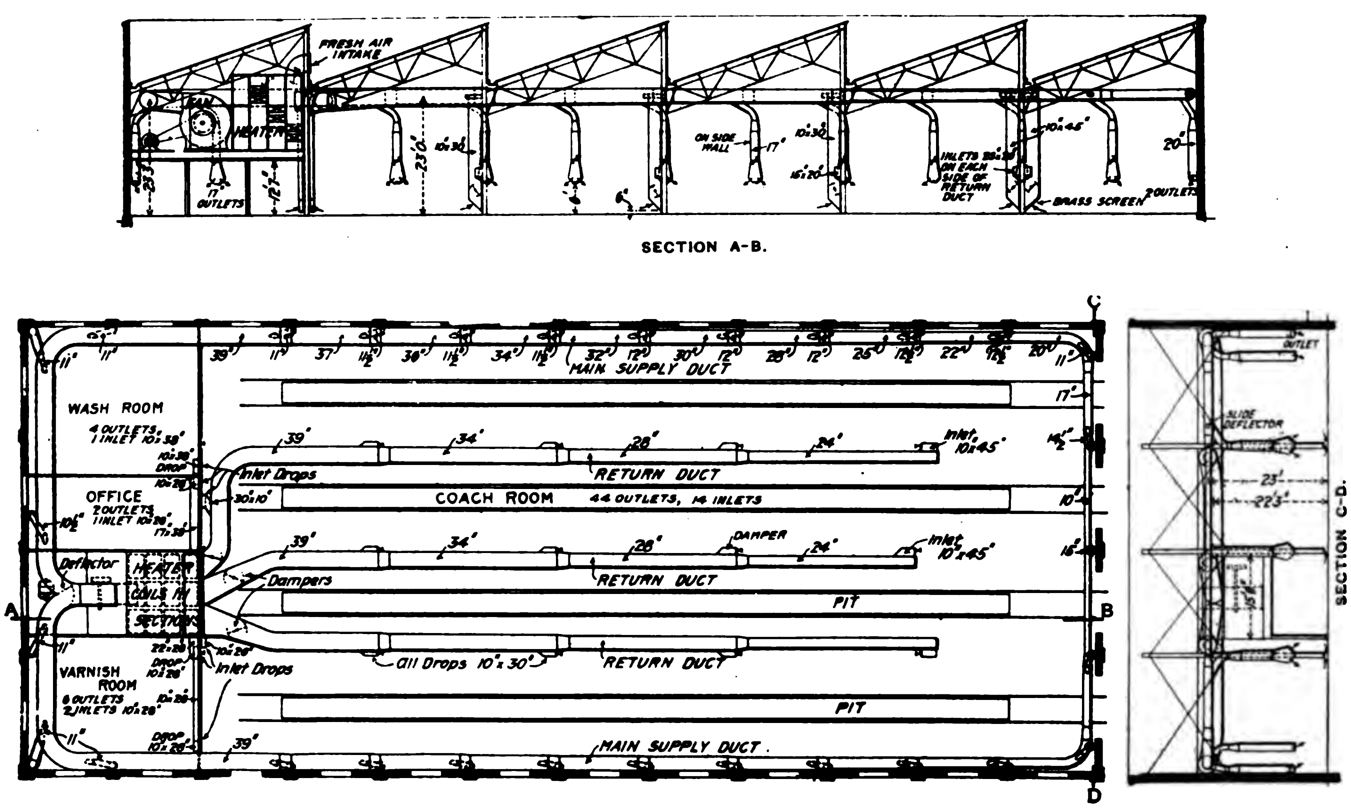
PLAN OF PAINT SHOP AT BURNSIDE, ILL., I. C. R. R.



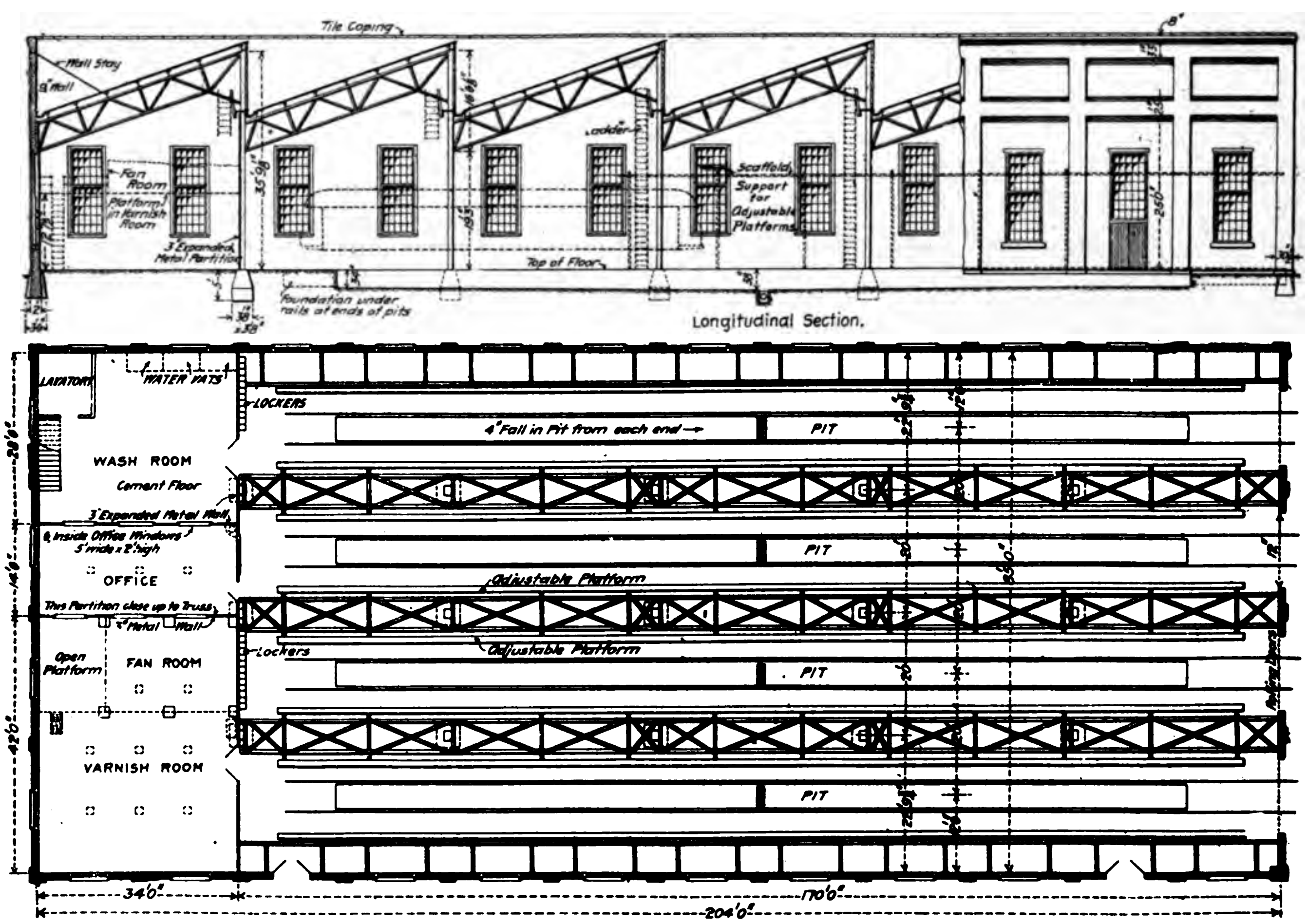
PARTIAL PLAN OF PASSENGER CAR REPAIR SHOP AT COLLINWOOD, OHIO, L. S. & M. S. RY.



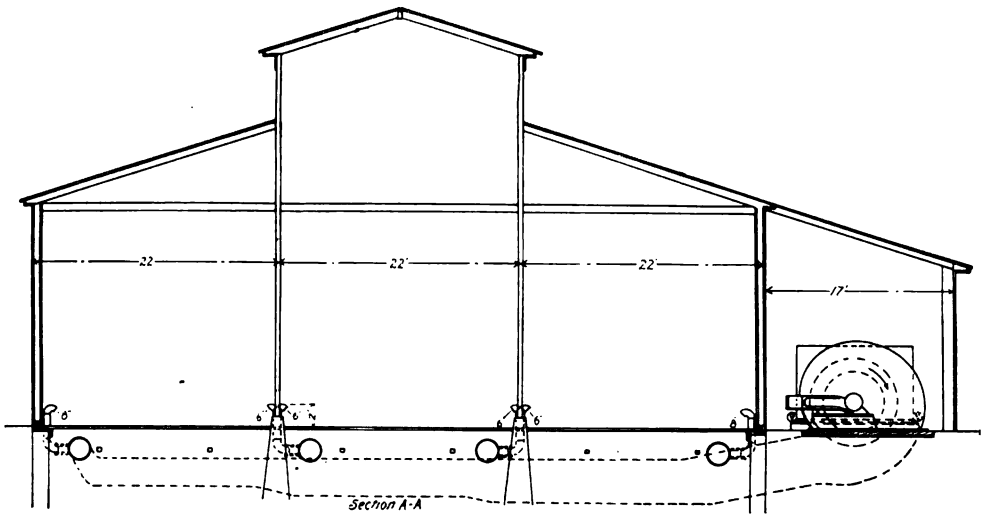
PARTIAL PLAN OF PASSENGER CAR PAINT SHOP AT COLLINWOOD, OHIO, L. S. & M. S. RY.



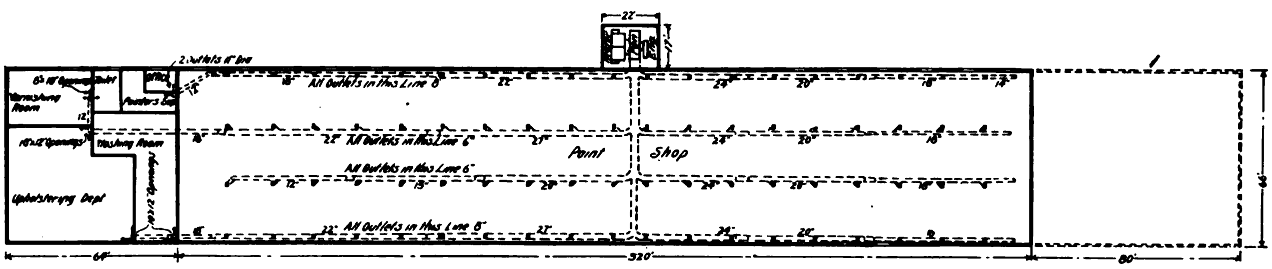
ARRANGEMENT OF HEATING SYSTEM IN PAINT SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.



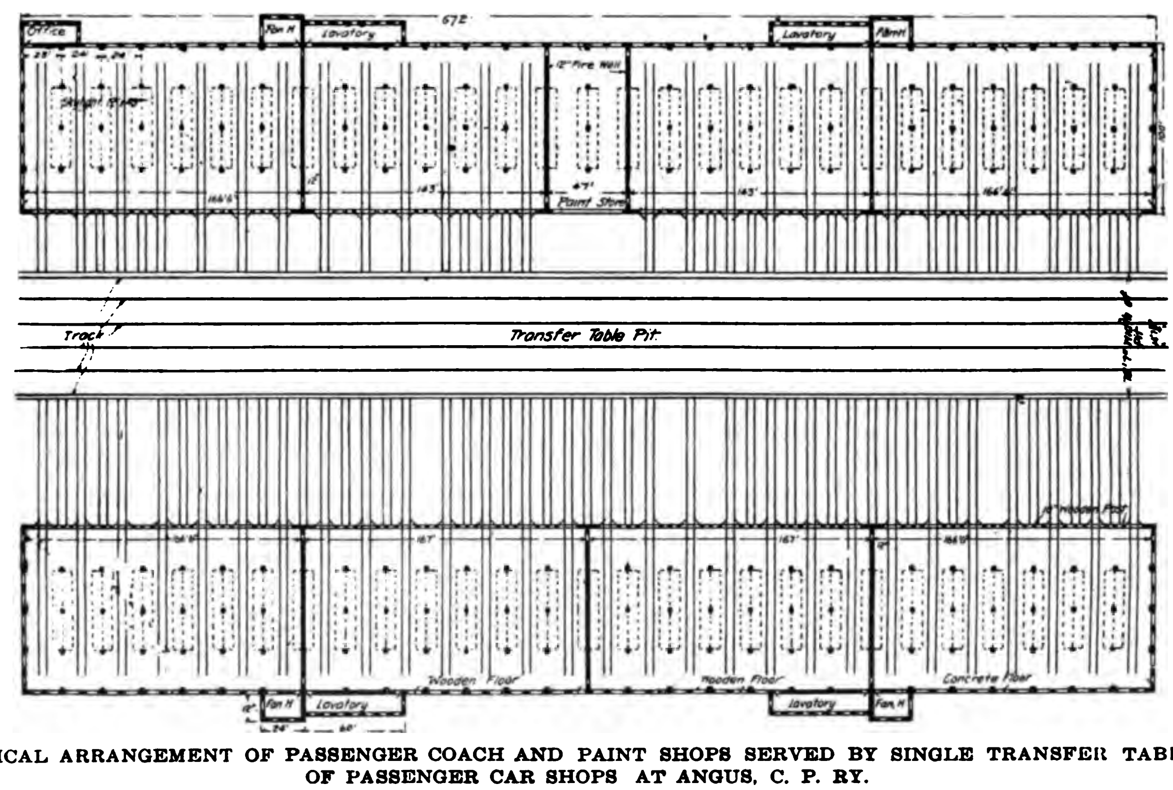
PLAN, PARTIAL SECTION AND ELEVATION OF PASSENGER CAR PAINT SHOP AT McKEES ROCKS, PA., P. & L. E. R. R.



CROSS SECTION OF PAINT SHOP, SHOWING LOCATION OF FAN, DISCHARGE PIPE, DISTRIBUTING PIPES AND OUTLETS AT MIDDLETOWN, N. Y., N. Y. O. & W. RY.



PLAN OF PAINT SHOP, SHOWING LOCATION OF DISTRIBUTING PIPES AND OUTLETS AT MIDDLETOWN, N. Y., N. Y. O. & W. RY.



TYPICAL ARRANGEMENT OF PASSENGER COACH AND PAINT SHOPS SERVED BY SINGLE TRANSFER TABLE—PLAN OF PASSENGER CAR SHOPS AT ANGUS, C. P. RY.

Railway Shop Up To Date

Chapter VIII

PLANING MILL

LOCATION.

THE planing mill is naturally located to provide facility in receiving stock in large bulk and for delivering it conveniently to the points of greatest consumption. As the lumber yard covers a large area it is placed at one end or side of the property, and as this supplies the planing mill, the mill building is usually at one side of the territory covered by the shop buildings. It is so situated as to give ready access to the rough lumber and pass stock through the various operations until the finished material is ready for delivering after passing in natural sequence over the shortest and most direct route.

The freight car shop consumes the greater portion of the output of the planing mill, so that the logical position for this building is between the lumber yard, dry lumber shed, dry kiln and the freight car shop. This provides a convenient arangement for ease in handling both rough and finished work. Where both freight car construction and repair work are carried on at the plant, the mill is the point of centralization of a large area and the rough material is directed toward this shop and delivered from it to each point of consumption for the different classes of work.

As the volume of material delivered to the passenger car department, either for construction or repair, is comparatively a very small per cent of that delivered to the freight car department, the location of the mill with regard to the passenger car department is of secondary importance. At the same time, however, the shorter the distance to this department and the more direct the route, the more economical will be the delivery of material and the greater the output of the department.

The planing mill also handles a certain amount of material for the locomotive department, for the engineering department, as well as for general repair work constantly arising from time to time. As there is, then, more or less general delivery to be provided for the mill building should be situated adjacent to the principal avenue of distribution and where this is a crane served runway, or midway as it is called, the mill is commonly placed contiguous to the midway.

BUILDING.

As in the case of most of the other principal buildings of the railroad shop plant a long narrow building lends itself most readily to the requirements of the planing mill. In view of the varying conditions governing the demands upon the planing mill—whether providing for construction or repair, the consumption of lumber by departments other than the car departments—there is not sufficient similarity in the size of the mill buildings of the many shops throughout the country to justify an attempt to formulate a rule determining the size of the floor area in proportion to any given unit, such as working space per locomotive, freight car or passenger car, number of freight cars per day, or passenger cars turned out per month.

At the Angus shops of the Canadian Pacific, including locomotive, freight car construction and passenger car departments, the dimensions of the mill are 500 feet by 125 feet, providing an area of 62,500 square feet. At Collinwood, on the L. S. & M. S. where locomotive, freight car repair, freight car construction and passenger car repair are carried on, the mill is 300 feet by 70 feet, giving an area of 21,000 square feet. At Readville, where the plant is devoted entirely to freight and passenger car work, the mill is 350 feet by 125 feet, an area of 43,750 square feet. At the D., L. & W. freight car building and repair shops at Scranton, the mill is 400 feet by 90 feet, providing an area of 36,000 square feet. At the East Decatur car shops of the Wabash the mill is 238 feet by 80 feet, an area of 19,040 square feet.

The floor area of the mill is necessarily large in proportion to the area covered by the machine equipment. The large volume of material passing through the mill, as well as its nature, size and shape, requires ample space for its disposition and movement and a large proportion of the stock uses temporary standing space both before and after passing each machine through which it travels.

The construction of the mill is in many respects similar to the other buildings of the car department. The roof trusses, supporting columns, etc., are of the same material and either wood or steel has been used in some of the most prominent shops recently constructed.

In the earlier and older shop buildings the roof structure was designed for greater stiffness than now required, to provide for the additional loads and the vibrations of shafts, pulleys, belts, etc. Power for the mill was usually delivered from an engine in an adjoining building, and all shafts, etc., were carried by the roof structure. The introduction of electrical apparatus and equipment has largely changed this and prevailing practice is to drive the larger machines by individual motors and the smaller machines in groups. The motors are usually placed upon the floor close to the machines, though the motors for group drive and for the smaller machines are sometimes suspended from the roof trusses.

NATURAL LIGHTING.

In mill buildings of the most recently constructed shops a noticeable feature is the provision for ample natural lighting. In some of them the space occupied by windows begins a short distance above the ground and extends as close to the roof as the limits of the wall will

allow. Light from windows in the wall is supplemented by skylights in the roof. At Collinwood the skylight is 260 feet long by 36 feet 6 inches wide and provides an area equal to 45 per cent of the area of the roof. At Angus there are 23 skylights in the roof, arranged transversely, and each skylight is 29 feet by 10 feet 4 inches in size. The absence of belts, shafts, pulleys, etc., in a planing mill adds materially to the efficient distribution of light and freedom from shadows.

DISTRIBUTION OF MATERIAL.

Convenience in the distribution of material necessitates its entrance at the end of the mill adjacent to the lumber yard and delivery at the other end. This requires large doors in the ends of the building and delivery tracks extending the full length of the building. Larger planing mills are equipped with two tracks traversing the building and the spaces which they occupy are kept open for the movement of light wagons or buggies, as well as for the transportation of push cars. In accord with the general sentiment in favor of standard gauge industrial tracks for delivery and distribution of material, the tracks through the mill are more commonly of standard gauge.

In the mill building at Kingsland, on the D., L. & W., there is a third rail between the rails of the standard gauge track, making a narrow gauge track for connection with the narrow gauge industrial system of the plant. Two other narrow-gauge tracks in the mill connect with the general industrial system of tracks. At the Scranton shops of the same road, the mill is served by narrow gauge industrial tracks, as well as being entered by a standard gauge track from the lumber yard.

Serving the mill building by tracks of standard gauge provides the advantage of allowing cars of lumber to be switched into the building and unloaded near the machines, thus reducing the cost of handling and removing the additional expense of unloading and stacking in the yard. Such a method is not practical at all times, but some shops make a practice of delivering a certain amount of material on order, direct to the mill and unloading it at night where it will be ready for the regular shop force in the morning.

The shop tracks are sometimes supplemented by short stub tracks immediately outside of the building for temporarily storing truck loads of lumber. A convenient and practical arrangement for the delivery of truck loads of material both to and from the planing mill is the provision of a small hand transfer table, operating in a shallow pit, at each end of the building. This method is followed to good advantage at Angus and the transfer tables permit convenient access to the several tracks of the lumber yard, mill building, car erecting shop or general delivery.

The use of side doors in the wall of the building near the dry kiln or dry lumber storage shed facilitates the rapid delivery of material. Such a method permits material to follow the most direct route from the point of storage to the machines through which it will pass. Not only is this delivery quicker, but it relieves congestion around the end doors where sills and other heavy material enter the building.

FLOORS.

Wooden floors prevail generally in the planing mill.

ARRANGEMENT OF MACHINES.

Among the most important features of the planing mill is the arrangement and distribution of machines to provide for the progressive movement of material in natural sequence and to provide for handling bulky and heavy pieces of stock, as well as a large volume of small material. There are many very interesting examples illustrating great care in the layout of machines so that the work will progress, naturally avoiding the necessity of moving timber backward in its course.

The layout of machines is usually such that those for machining sills occupy a large portion of one side of the mill, while the remaining large portion is occupied by the various machines used in light lumber dressing. The arrangement of machines in sequence in that section through which the heavier material passes is naturally of greater importance than in the section for lighter material. The arrangement of the tools in the paths of progress are such as to bring the material to the roughing machines first, through the supplemental machines and finally to those for finishing.

In both sections, the most satisfactory arrangement provides for the movement of material in such manner that it will touch the floor as little as possible. For instance, in the path of sills are placed wooden skids of about the same height as the machine tables, so disposed that the sills may be moved longitudinally or transversely according as the machines are situated in its path, but always the general movement is forward.

The systematic arrangement of skids in the path of other material is more difficult than in the case of the sills. However, it is often possible to arrange such paths over short distances and for certain classes of work. Where this cannot be done, the most economical method is to deliver small material to each machine in wagon loads and load it directly upon a wagon on the other side of the machine. In the rapid handling of material much work is done to templates, thereby minimizing the labor of laying out.

The planing mill at Angus is operated in two distinct departments, one of which is under the jurisdiction of the foreman of the freight car erecting shop and is used for dressing freight car material only. The other section is under the jurisdiction of the passenger car foreman and serves his department only. The machines in both departments are arranged largely in straight lines and every facility is provided for the rapid movement of lumber with minimum amount of handling.

SHAVINGS EXHAUST SYSTEM.

An essential feature of the planing mill is the collector system for disposing of shavings, dust, etc. This system

is connected with the boiler room where one or more boilers of the power plant are fed by shavings and chips from the mill. Exhaust blowers are located at convenient positions within the building and from them suction pipes lead to hoods covering the cutters or saws of the various machines, so as to draw in instantly all chips and shavings produced by the cutting tools. Floor sweep openings are provided at those machines which can not be served to advantage by hoods over the cutters and at various places to accumulate sweepings from the floor. Everything that may be consistently raked or swept to these openings will be drawn away quickly by the suction. The collector system is usually so effectual that it will readily remove rather large sticks and blocks. The result of this system is that the planing mill may be kept in a very neat and clean condition at a comparatively small expense while the delivery of refuse to the boiler room is at a nominal cost.

The shavings exhaust system at Angus employs 17 fans from 50 to 90 inches in diameter, and running from 665 to 1,700 revolutions per minute, the maximum speeds of the fans in the planing mill being 880 feet per minute. The longest run of conduit in this system is 700 feet. In deciding upon the capacity for the equipment computations were made upon the difference between finished and rough dimensions of timber in a 30-ton box car. This amounts to 860 feet board measure, or 72½ cubic feet per car, and this volume will fill two or three times that space when put into the form of shavings and sawdust.

List of Wood-Working Machinery in Representative Railway Shops—Planing Mill

CANADIAN PACIFIC—ANGUS.

Machine.	Size.	Maker.
2 Planers and sizers	No. 8	Berlin Machine Co.
Inside moulder	No. 125	Berlin Machine Co.
2 Self feed rip saws	No. 3	Greenlee Bros & Co.
Self feed rip saw	No. 3	Greenlee Bros. & Co.
Vertical heavy automatic cut-off saw	No. 5	Greenlee Bros. & Co.
Heavy vertical cutoff saw	No. 5	
Extra range automatic car gaining machine		Greenlee Bros. & Co.
2 Horizontal tenoners	No. 5	Greenlee Bros. & Co.
Special automatic vertical car sill tenoning machine	No. 4	
Vertical boring machine	4-spindle	Greenlee Bros. & Co.
Extra range heavy car boring machine		Greenlee Bros. & Co.
Heavy vertical boring machine	5-spindle	Greenlee Bros. & Co.
Extra car range boring machine		Greenlee Bros. & Co.
Vertical boring machine	3-spindle	Greenlee Bros. & Co.
Standard heavy vertical car boring machine	3-spindle	Greenlee Bros. & Co.
Boring machine	3-spindle	Greenlee Bros. & Co.
Heavy single spindle radial horizontal borer		Greenlee Bros. & Co.
2 Standard heavy vertical hollow chisel mortisers		Greenlee Bros. & Co.
H. C. mortising machine	No. 14	Greenlee Bros. & Co.
3 Self feed rip saws	No. 1½	Greenlee Bros. & Co.
Large car ripping saw	No. 3	Fay & Egan Co.
2 Improved rip saws	No. 2	Fay & Egan Co.
Band saw		Fay & Egan Co.
Band saw	No. 00	Fay & Egan Co.
Car mortiser and borer	No. 72	Fay & Egan Co.
4 Automatic cutoff saws	No. 1	Greenlee Bros. & Co.
Automatic cutoff saw	No. 2	Greenlee Bros. & Co.
2 Planers and matchers	No. 46	Berlin Machine Co.
Planer and matcher	No. 44	Berlin Machine Co.
Band saw	No. 3	MacGregor-Gourlay Co.
Automatic vertical cutoff saw		Fay & Egan Co.
Vertical automatic cutoff saw and gainer	No. 3	Greenlee Bros. & Co.
Vertical heavy automatic cut-off saw	No. 6	Greenlee Bros. & Co.
Vertical boring machine	3-spindle	Greenlee Bros. & Co.
Medium heavy boring machine	3-spindle	Greenlee Bros. & Co.
Perfection buzz planer	20-ins.	MacGregor-Gourlay Co.
Shaping machine		MacGregor-Gourlay Co.
Dimension saw		MacGregor-Gourlay Co.
Outside moulding		MacGregor-Gourlay Co.
Small rip saw		MacGregor-Gourlay Co.
Rip saw		MacGregor-Gourlay Co.
Improved rip saw		MacGregor-Gourlay Co.
Large band saw		MacGregor-Gourlay Co.
Self feed rip saw		MacGregor-Gourlay Co.
Chain saw mortiser		
Band saw		MacGregor-Gourlay Co.
Burring saw		J. Bertram & Sons
Large rip saw		J. Bertram & Sons
Small rip saw		Cowan & Co.
Swing saw		MacGregor-Gourlay Co.
Swing saw		
Dimension planer		Fay & Egan Co.
Buzz planer		MacGregor-Gourlay Co.
Surface planer	No. W 14	J. Bertram & Sons
Dimension planer		MacGregor-Gourlay Co.
Large matcher and dimension planer	4-headed	J. Bertram & Sons
Matcher and dimension planer	4-headed	Cant-Gourlay
Sticker	4-headed	MacGregor-Gourlay Co.
H. C. mortiser		Atlantic
Small sash and door mortiser		
H. C. mortiser		Atlantic
Vertical boring machine	3-spindle	Fay & Egan Co.
Single horizontal borer		
Vertical gainer		Fay & Egan Co.
Horizontal gainer		J. Bertram & Sons
Large matcher	4-headed	Fay & Egan Co.
Large horizontal tenoner		
Light tenoning machine		McKechnie & Bertram
Double headed shaper		MacGregor-Gourlay Co.
Vertical end tenoning machine		McKechnie & Bertram
Sticker	4-headed	MacGregor-Gourlay Co.
H. C. mortiser		Greenlee Bros. & Co.
Boring machine	5-spindle	Greenlee Bros. & Co.
2 Iron frame swing saws		
Boring machine	3-spindle	
Horizontal gainer		Fay & Egan Co.
Boring machine	5-spindle	Greenlee Bros. & Co.
Self feed saw		Greenlee Bros. & Co.
Variety wood-worker	No. 2	Fay & Egan Co.
P. H. shaper		MacGregor-Gourlay Co.
Horizontal tenoner		Buck
Car tenoner	No. 5	Fay & Egan Co.
2 Horizontal gainers		J. Bertram & Sons
Planer and matcher	No. 24	Berlin Machine Co.
Single horizontal boring machine		
Vertical car sill tenoning machine		
Gainer and checker		
Rip saw		
2 Swing saws		
Iron frame swing saw		

D., L. & W.—SCRANTON (KEYSER VALLEY).

Machine.	Size.	Maker.
Double planer and matcher		Berry & Orton Co.
Swing saw	30 ins	D. L. & W. R. R.
Rip saw	up to 24 ins	D. L. & W. R. R.
Double planer and matcher	No. 17	S. A. Woods Machine Co.
Outside moulder	6 ins	C. B. Rogers & Co.
Cross-cut saw	40 ins. No. 188	S. A. Woods Machine Co.
Sill tenoner	No. 0	C. B. Rogers & Co.
Cross boring machine	No. 350	S. A. Woods Machine Co.
Boring machine, 4 spindles	No. 325	S. A. Woods Machine Co.
Vertical car boring machine	3 spindles	C. B. Rogers & Co.
Rip saw		D. L. & W. R. R.
Automatic cross-cut saw	36 ins. No. 3	Fay & Egan Co.
Rip saw	24 ins. No. 175	S. A. Woods Machine Co.
Sticker	5-head	Housten
Upright shaping machine	No. 0	C. B. Rogers & Co.
Matcher		Fay & Egan Co.
Gaining machine		S. A. Woods Machine Co.
Gaining machine (pneumatic)		D. L. & W. R. R.
Hollow chisel, hollow mortiser	No. 7	S. A. Woods Machine Co.
3-spindle boring machine		Berry & Orton Co.
2 Wood turning lathes		
Saw grinding and sharpening machine	No. 231	S. A. Woods Machine Co.
Automatic knife grinder	No. 221	S. A. Woods Machine Co.
Band saw filer		Chas. E. Wright
Band saw	36 ins. No. 3	C. B. Rogers & Co.
Swing saw	22 ins. No. 232	S. A. Woods Machine Co.
Hand planer		C. B. Rogers & Co.
Door and sash tenoning machine	No. 3½	Fay & Egan Co.
Extra heavy sizer	6-roll, 4 sides No. 111	Fay & Egan Co.
Flooring machine, fast speed	No. 17	Fay & Egan Co.
Double cutting-off machine	40 ins. No. 5	Greenlee Bros. & Co.
Vertical car boring machine, 4 spindles		Greenlee Bros. & Co.

Machine	Size	Maker
Vertical car boring machine, 4 spindles, with universal attachment		Greenlee Bros. & Co.
Heavy self-feed saw	No. 3	Fay & Egan Co.
Combination vertical borer and gainer	No. 3	Greenlee Bros. & Co.
Small vertical hollow chisel mortiser	No. 11	Greenlee Bros. & Co.
Hollow chisel mortiser	No. 8	Greenlee Bros. & Co.
Vertical car tenoning machine	No. 4	Greenlee Bros. & Co.
Double tenoning machine	No. 540	Greenlee Bros. & Co.
Car brace cutting-off machine		Greenlee Bros & Co.
Cross-cut saw		D. L. & W. R. R.
Wood turning lathe		
Cut-off saw	22 ins. No. 2	Fay & Egan Co.
Groove saw	12 ins	
Box bound matcher		
Grindstone		
Heavy combined buzz planer	No. 97	S. A. Woods Machine Co.
Hollow chisel sharpener		Atlantic
Band resawing machine		American Wood Wkg. Mach. Co.
Sharpener for circular saw		Atlantic
Band saw filing and setting machine		Atlantic
Lathe		
Rip saw		S. A. Woods Machine Co.
Jig saw		
Single surfacer	No. 88	S. A. Woods Machine Co.
Band saw		C. B. Rogers & Co.
Emery grinder and dust guard machine		
Mortiser		R. Ball & Co.
Shaper		H. D. Stovers
Knife grinder		

L. S. & M. S. RY.—COLLINWOOD.

Machine.	Size	Maker	Motor H. P.
Timber planer	Four-side	Fay & Egan	35
Timber planer	Four-side	Amn. W. W. Mach. Co.	35
"Lightning" matcher		Fay & Egan Co.	25
Matcher	No. 27	S. A. Woods Mach. Co.	35
Automatic cut-off saw	No. 6	Greenlee Bros. & Co.	20
Vertical end tenoner	No. 4	Greenlee Bros. & Co.	15
Rip saw	No. 4	S. A. Woods Mach. Co.	20
Cut-off saw, automatic	No. 4	Greenlee Bros. & Co.	15
Vertical saw and gainer	No. 8	Fay & Egan Co.	20
Automatic cut-off saw	No. 3	Greenlee Bros. & Co.	15
Rip saw	No. 3	Greenlee Bros. & Co.	20
Automatic saw and dado		Greenlee Bros. & Co.	15
Bevel band saw	40 ins	Williamsport Mach. Co.	10
Band saw	42 ins	Fay & Egan Co.	7½
Horizontal mortiser	H. C.	Fay & Egan Co.	15
Vertical mortiser and borer	No. 7	Greenlee Bros. & Co.	15
Gainer	No. 3	Fay & Egan Co.	15
Tenoner	No. 70	Fay & Egan Co.	7½
Horiz. boring machine	Four-spin	Greenlee Bros. & Co.	10
Jointer		Fay & Egan Co.	7½
Pony planer	24 ins	S. A. Woods Mach. Co.	10
Gainer with 4-spindle borer	No. 3	Greenless Bros. & Co.	10&15
Shaper	Double head	Grosvenor	7½
Automatic saw filer			
Automatic knife grinder			
Automatic saw grinder			7½
Band Saw Filer			
Wood lathe		Fay & Egan Co.	

L. & N. R. R.—SOUTH LOUISVILLE.

Machine.	Size.	Maker.	Motor H. P.
Short sill dresser	20-in. blade	S. A. Woods Mach. Co.	100
Cut-off saw	40-in.	Greenlee Bros. & Co.	15
Cut-off saw	40-in.	Greenlee Bros. & Co.	
Matcher	15-in. blade	Fay & Egan Co.	30
Matcher	10¼-in. bl'de	Fay & Egan Co.	50
Matcher	10¼-in. bl'de	Fay & Egan Co.	30
Cut-off saw	34-in.	Fay & Egan Co.	8
Cut-off saw	34-in.	Fay & Egan Co.	14
Cut-off saw	32-in.	Fay & Egan Co.	30
Surfacer	26-in. blade	Fay & Egan Co.	
Heavy rip saw	28-in. No. 153	S. A. Woods Machine Co.	
Light rip saw	28-in.	Greenlee Bros. & Co.	
Borer	5 spindle	Greenlee Bros. & Co.	30
Vertical hollow chisel mortiser with traveling table	No. 154	Fay & Egan Co.	
Sill tenoner	3 cutters	Fay & Egan Co.	30
Gainer		Greenlee Bros. & Co.	14
Swing cut-off saw	24 in.	L. & N. R. R.	5
Borer	5 spindle	Fay & Egan Co.	
Vertical hollow chisel mortiser with traveling table	No. 154	Fay & Egan Co.	18
Automatic car gainer	No. 150	Fay & Egan Co.	
Universal car tenoner		Fay & Egan Co.	
Horizontal borer		Fay & Egan Co.	
Vertical single spindle borer		Bentel & Margedant	50
Band saw	No. 2	Fay & Egan Co.	
Dimension planer	24 in. blade	Fay & Egan Co.	
Universal wood-worker		Fay & Egan Co.	8

M. P. RY.—SEDALIA.

Machine.	Size.	Maker.
Universal wood worker	16-in.	Greenlee Bros. & Co.
Variety wood worker	No. 62	Fay & Egan Co.
Four-side moulder	No. 12	Fay & Egan Co.
Surfacer	30-in.	S. A. Woods Machine Co.
Six-roll cylinder planer	No. 129	Fay & Egan Co.
Vertical car tenoner		Fay & Egan Co.
Tenoning machine	No. 6	Fay & Egan Co.
Car gaining machine		Fay & Egan Co.
Hand gaining machine		Fay & Egan Co.
Mortiser		Greenlee Bros. & Co.
Mortiser	No. 300	S. A. Woods Machine Co.
Four-spindle horizontal boring machine		Greenlee Bros. & Co.
Cut-off saw	No. 3	Fay & Egan Co.
Cut-off saw	No. 2	Fay & Egan Co.
Swing saw	No. 3	Fay & Egan Co.
Self-fed rip saw	No. 3	Fay & Egan Co.
Band saw	No. 1	Fay & Egan Co.
Band saw	No. 3	Fay & Egan Co.
Scroll saw	No. 3	Fay & Egan Co.
Automatic saw sharpener		
Band saw setter	No. 3	Fay & Egan Co.
Knife grinder		Fay & Egan Co.
Fox trimmer		
Superior setting down machine		
Raymond wiring machine		
Raymond large turning machine		
Raymond small turning machine		
Groover	20-in.	Buffalo
Double seamer		Moore
Beader	No. 2	Niagara

List of Wood-working Machinery in Representative Railway Shops—Cabinet Shop.

CANADIAN PACIFIC RAILWAY—ANGUS.

Machine.	Size.	Maker.	Motor H. P.
Double combination glue spreader			2
Window blind mortiser		J. Bertram & Sons	
Window blind slot mortiser		McGregor, Gourley & Co.	5
Boults carver		McGregor, Gourley & Co.	
Royal invincible sander		Berlin Machine Works	40
Jig saw		C. P. R.	
Sash and door mortiser		J. Bertram & Sons	7½
Band saw	No. 3	McGregor, Gourley & Co.	
Double tenoning machine	10 in to 6 ft. 6 in.	McGregor, Gourley & Co.	15
Chain mortiser	No. 66	New Britain Mach. Works.	5
Sash sticker		McGregor, Gourley & Co.	
Finishing saw, mitering work		Herbert Baker & Co.	10
Band saw	36 in. wheel	McGregor, Gourley & Co.	
Inside moulder	4-headed	McKechnie & Bertram	20
Pony planer		Fay & Egan Co.	
Grindstone	72-in.	Niles-Bement-Pond Co.	
Emery wheel		C. P. R.	
Dimension saw table	16 ins. wide, 3 ins. thick	McGregor, Gourley & Co.	20
Saw, double-headed	16 ins.	McGregor, Gourley & Co.	
Perfection buzz planer and jointer		McGregor, Gourley & Co.	
Dimension planer, sizing and straightening		McGregor, Gourley & Co.	15
Swing saw	16-in.	C. P. R.	5
Feed rod machine	¼ to 1 1-12 in.	McGregor, Gourley & Co.	5
Wood lathe	24-in.	McGregor, Gourley & Co.	5
Wood lathe	20-in.	Smith & Coventry	
Swing saw	16-in.	C. P. R.	5
Universal Woodworker		Fay & Egan Co.	15
Rip saw	12-in.	McGregor, Gourley & Co.	
Panel planer		McGregor, Gourley & Co.	
Tenoning machine		McGregor, Gourley & Co.	20
Rip and cross cut saw	14-in.	McGregor, Gourley & Co.	
Inside moulder	3 sided	McGregor, Gourley & Co.	
Chain mortiser	No. 66	New Britain Mach. Works.	15
Chain grinder		New Britain Mach. Works.	
Shaping machine		McGregor, Gourley & Co.	10
Shaping machine		McGregor, Gourley & Co.	
Boring machine	Single spindle	McGregor, Gourley & Co.	10
Friezing machine		Fay & Egan Co.	
Carver	2-spindle	Blouts	

L. S. & M. S. RY.—COLLINWOOD.

Machine.	Size.	Maker.
Sticker		American Wood Working Mach Co.
Jointer		Clement
Band saw	42 ins	Fay & Egan Co.
Tenoner	3½ ins	Fay & Egan Co.
Shaper	No. 3	Clement
Surfacer	7x24 ins.	Whitney
Scroll saw	No. 6	Fay & Egan Co.
Sander	84 ins	
Wood-carving machine		
Wood lathe		

Pattern lathe	24 ins.	Fay & Egan Co.
Universal saw bench		American Wood Working Mach. Co.
Sash mortiser		Greenlee Bros. & Co.
Combination rip and cut-off saw		S. A. Woods Machine Co.
Self-feed rip saw	No. 3	Greenlee Bros. & Co.

Tools in this list are belt driven from two line shafts.

L. & N. R. R.—SOUTH LOUISVILLE.

Machine.	Size.	Maker.	Motor H. P.
Carriage cut-off saw	No. 2	Fay & Egan Co.	
Rip saw		Bentel & Margedant	
Rip saw		Bentel & Margedant	
Planer and matcher	No. 8	Fay & Egan Co.	
Tenoning machine	No. 2	Fay & Egan Co.	30
Combination universal woodworker and moulder	No. 3	Fay & Egan Co.	
4-side 4-in. moulder	No. 1½	Fay & Egan Co.	
Pony planer	24-in. blade	Goodell & Waters Co.	
Mortiser	No. 71	Fay & Egan Co.	
Vertical double spindle boring machine	No. 2	Fay & Egan Co.	
Double spindle shaper	No. 2½	Fay & Egan Co.	
Mortiser and relisher	No. 93	Fay & Egan Co.	14
Combination saw and dado	No. 5	Fay & Egan Co.	
Single head shaper		Fay & Egan Co.	
Grindstone		L. & N. R. R.	
Sand papering machine	No. 4	Fay & Egan Co	18
Combination panel carver and friezer	No. 4	Fay & Egan Co.	
Plug cutter		Fay & Egan Co.	
Scroll saw		Fay & Egan Co.	8
Marquit veneer saw		L. & N. R. R.	
22-in. x 12-ft. lathe		Putnam Machine Co.	

List of Wood-Working Machinery in Representative Railway Shops—Pattern Shop

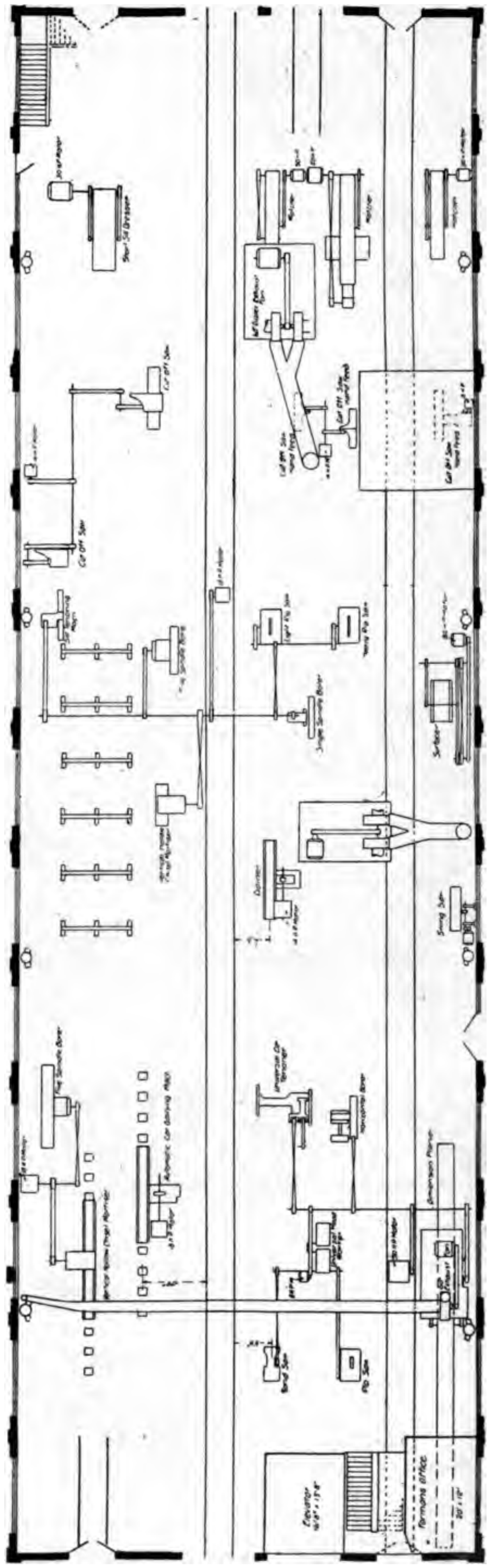
PENNSYLVANIA RAILROAD—SOUTH ALTOONA.

Machine.	Size.	Maker.	Motor H. P.
Rip saw	36x72 in. table	P. R. R.	5½
Rip saw	48x76 in. table	L. Wright	3½
Band saw		Berry & Orton	2½
Band saw, type B	½ in. saw blade	Oliver Machine Co.	3½
Lathe	25 and 50 in. swing, 8 ft. bed	Putnam Machine Co.	
Power band saw filing and setting mach.		Atlantic Works	
Drill press		P. R. R.	
Core box machine		J. A. Crane & Co.	
Grindstone	28 ins.		
Automatic knife grinder	30 ins. No. 40	Springfield Mfg. Co.	25
Lathe	20 ins. x 6 ft. 9 ins.	P. R. R.	
Lathe	30 ins. x 11 ft.	P. R. R.	
Lathe	30 ins. x 22 ft.	P. R. R.	
Face lathe	90 ins.	P. R. R.	
Band saw, type B	½ in. saw blade	Oliver Machine Co.	3½
Universal saw bench	14 in. saw	Oliver Machine Co.	3½
Universal saw bench	14 in. saw	Oliver Machine Co.	3½
Hand planer and jointer	20 ins.	Oliver Machine Co.	3½
Buzz planer and jointer		L. Power & Co.	3½
Heavy planer and surfacer	24 ins.	Atlantic Works	5½
Face plate lathe, type D		Oliver Machine Co.	3½
Planer	30 ins.	R. Ball & Co.	5½

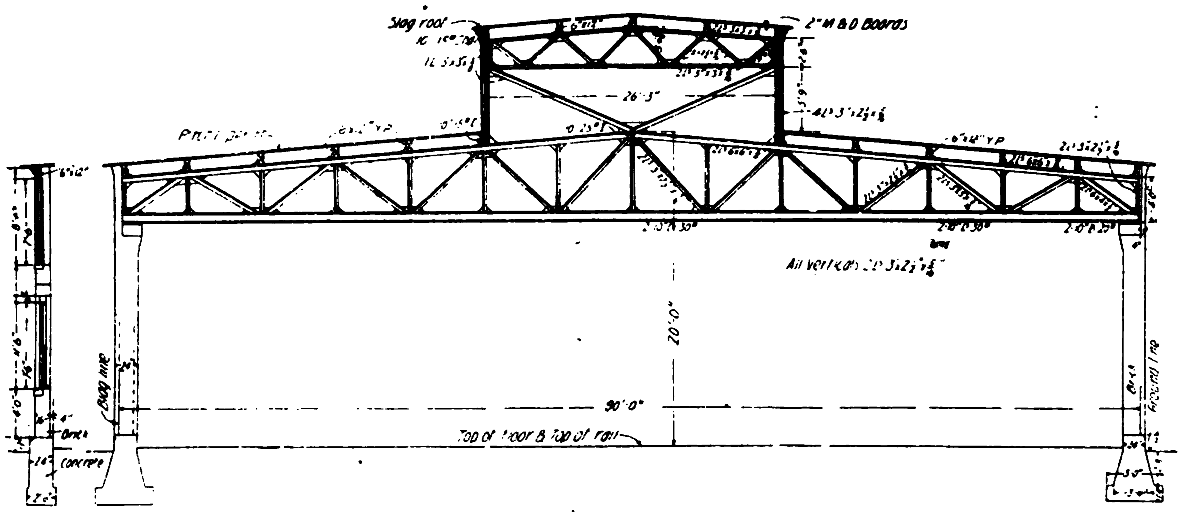
L. & N. R. R.—SOUTH LOUISVILLE.

Machine.	Size.	Maker.
Pattern makers' gap lathe	25 to 50 ins. swing, 10 ft. bed	Putnam Machine Co.
Wood lathe	16 ins. x 8 ft.	
Metal lathe	12 ins. x 4 ft.	Wm. Sellers & Co.
Oliver hand planer and jointer	20 ins.	Am. Wood Wkg. Mach. Co.
Hand surface planer	24 ins.	Fay & Egan Co.
Oliver Universal Saw Bench		American Wood Working Mach. Co.
Band saw		Fay & Egan Co.
Drill	20 ins.	W. F. & J. Barnes
Fox trimmer		Grand Rapids Machy. Co.
Crank shaper	18 ins.	Am. Wood Wkg. Mach. Co.
Grindstone		

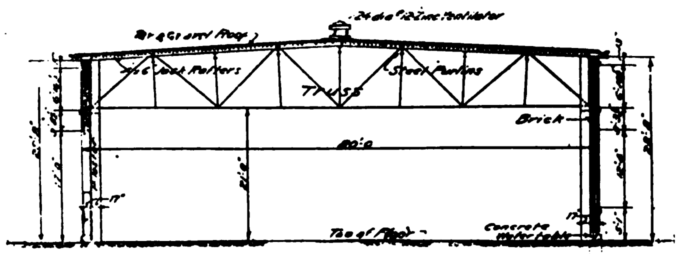
The machine tools are arranged in one group and driven by a 14-h.p. motor.



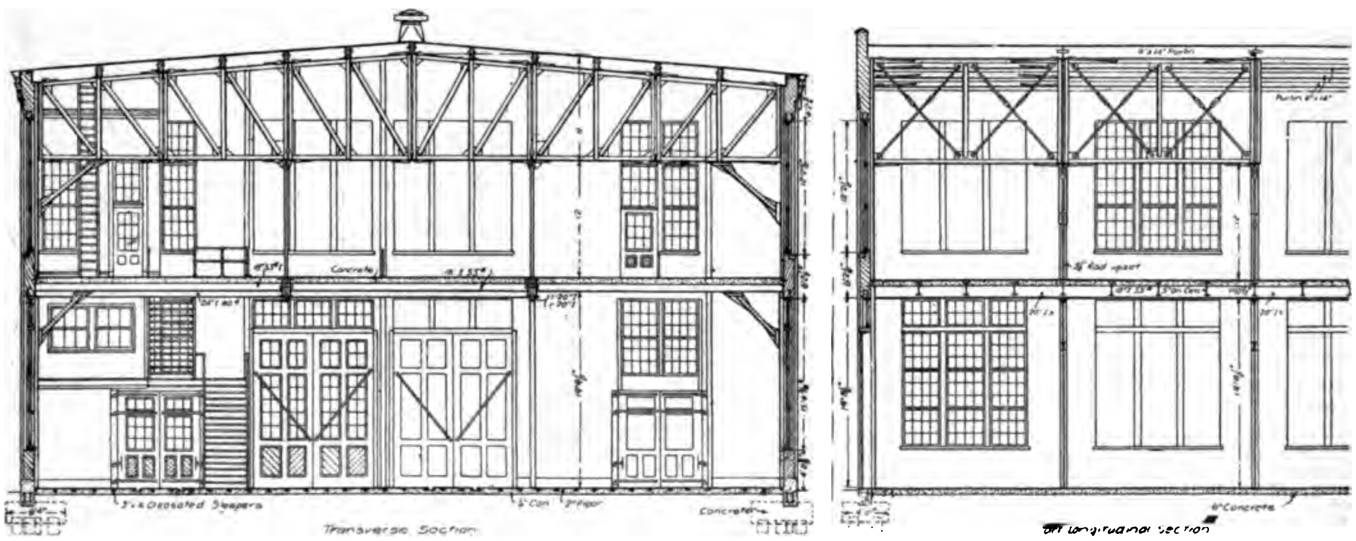
PLAN OF PLANING MILL, SHOWING LAYOUT OF EQUIPMENT AT SOUTH LOUISVILLE, KY., L. & N. R. R.



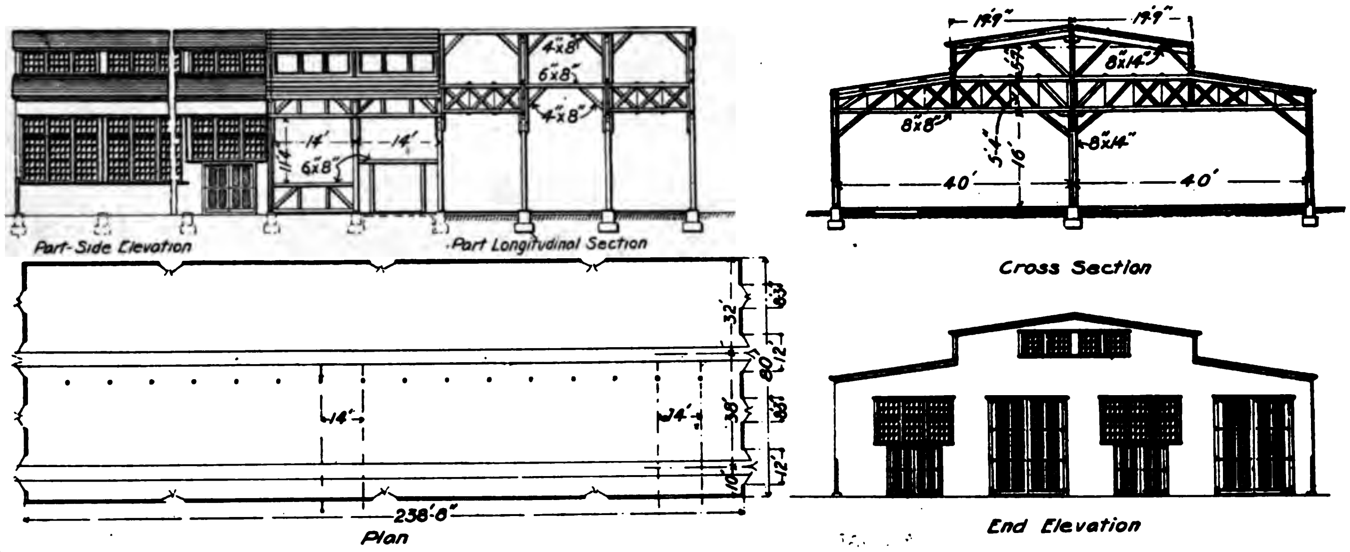
CROSS SECTION OF PLANING MILL AT SCRANTON, PA., D. L. & W. R. R



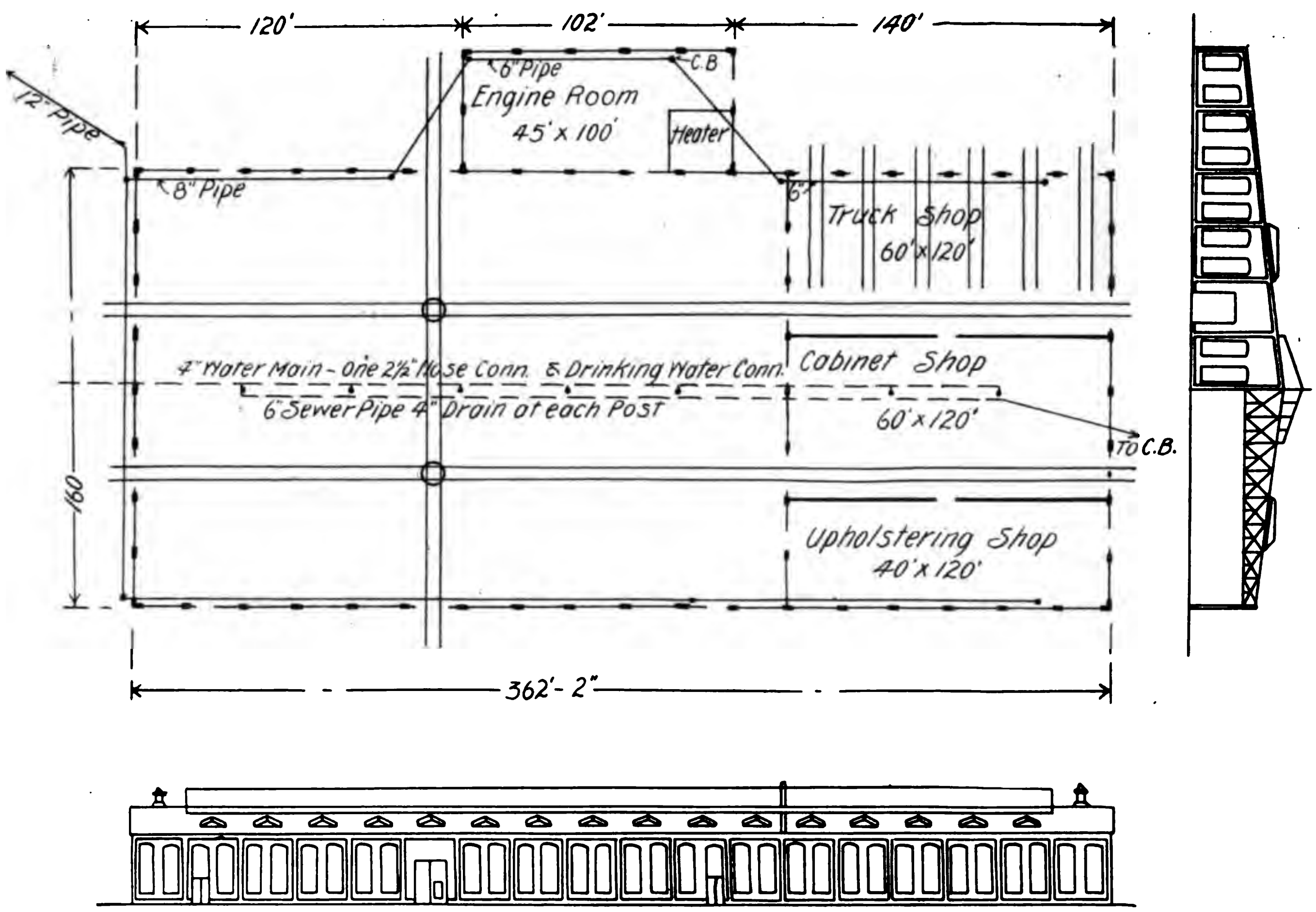
CROSS SECTION OF PLANING MILL AT SEDALIA, MO., M. P. RY.



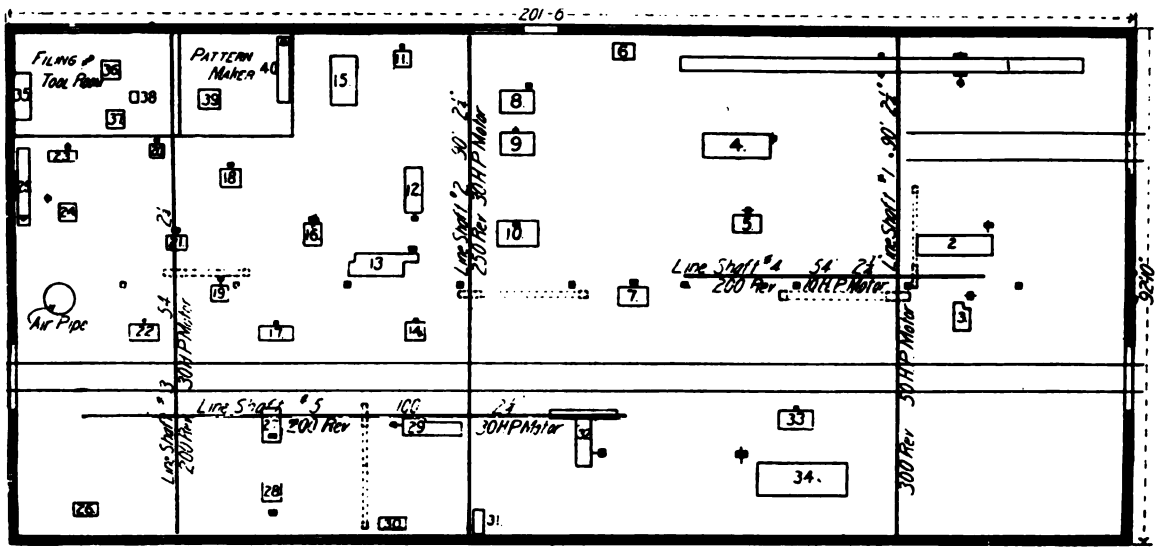
SECTION OF PLANING MILL AND COACH SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



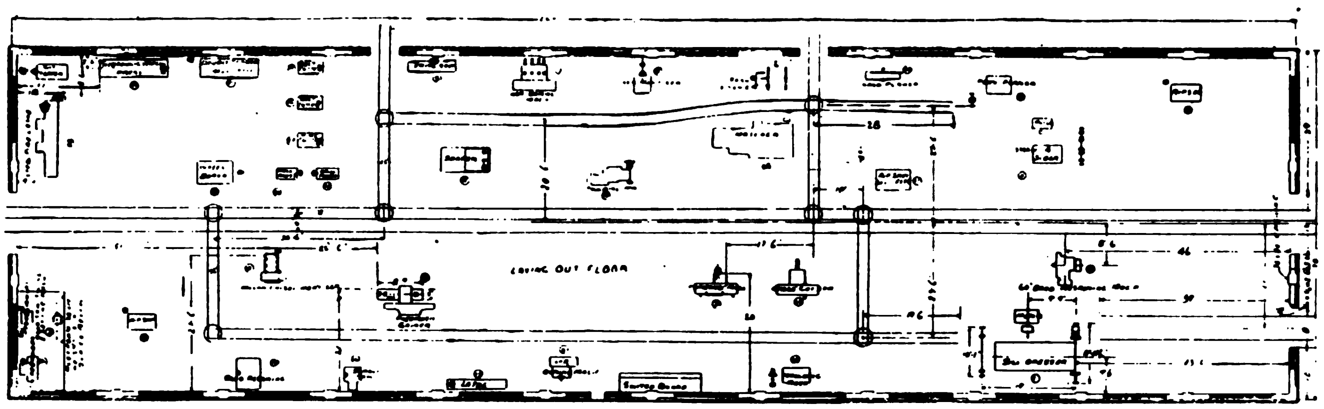
PLAN, ELEVATIONS AND SECTIONS OF PLANING MILL AT EAST DECATUR, ILL., WABASH R. R.



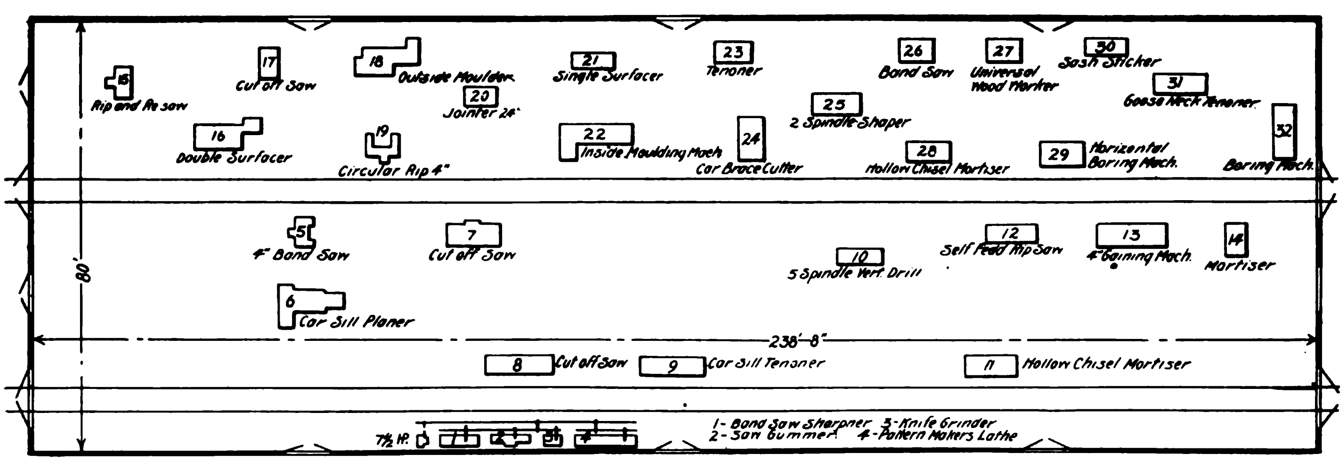
PLAN, ELEVATIONS AND PARTIAL CROSS SECTION OF PLANING MILL AT BURNSIDE, ILL., I. C. R. R.



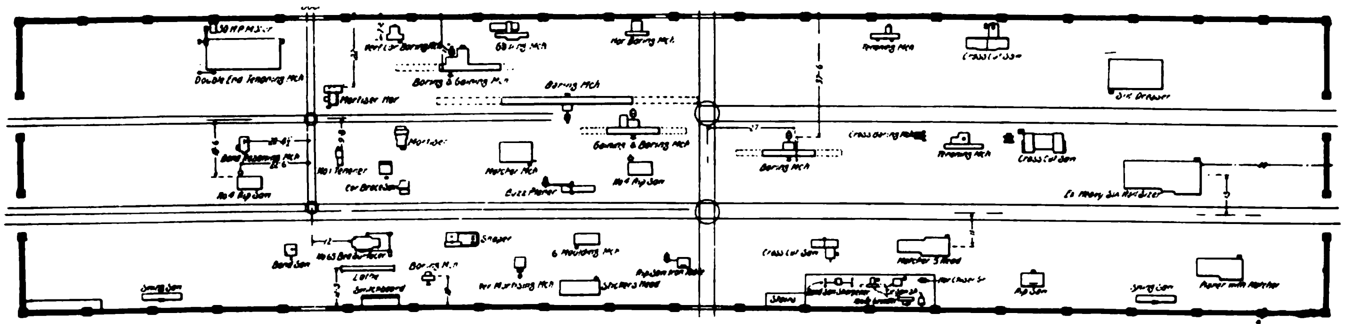
PLAN OF PLANING MILL AT OELWEIN, IOWA, C. G. W. R. R.



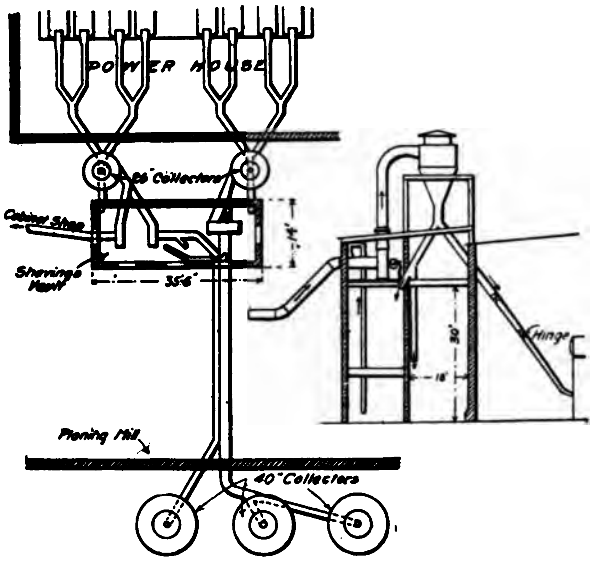
PLAN OF PLANING MILL AT KINGSLAND, N. J., D., L. & W. R. R.



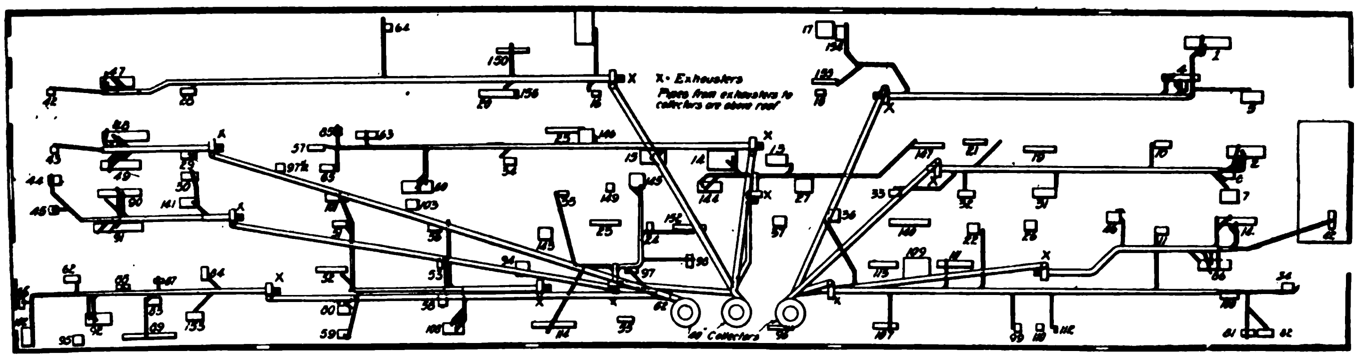
PLAN OF PLANING MILL AT EAST DECATUR, ILL., WABASH RY.



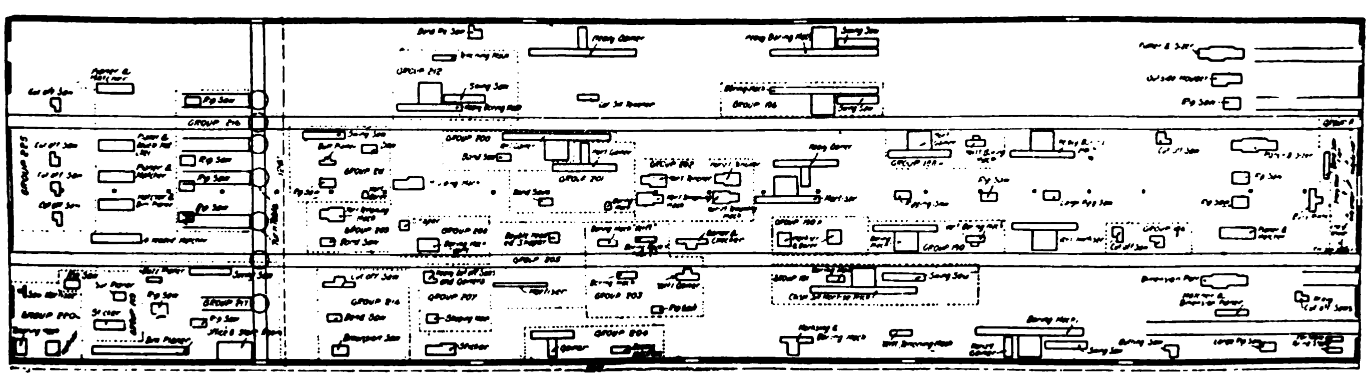
PLAN OF PLANING MILL AT SCRANTON, PA., D. L. & W. R. R.



EXHAUST SYSTEM FOR DELIVERY OF SHAVINGS FROM PLANING MILL TO POWER HOUSE AT ANGUS, C. P. RY.



PLAN OF PLANING MILL, SHOWING ARRANGEMENT OF SHAVINGS EXHAUST DUCTS, AT ANGUS, C. P. RY.



PLAN OF PLANING MILL AT ANGUS, C. P. RY.

Railway Shop Up to Date

Chapter IX.

FOUNDRY

UNTIL recent years the foundry was rare as a component part of a railway shop plant. Foundry work is entirely of a manufacturing nature and with the recent development of the large railway shop plant, the tendency toward the general introduction of the foundry as a principal department has become pronounced. Several railway general shops completed since the year 1902 include gray iron foundries as essential features and a number of shops now in course of construction include elaborate plans for foundry work. The tendency is to concentrate the foundry work for the entire system at the general shops, so that the foundry has not entered into the consideration of plans for minor and division shops.

A large number of shops have small brass foundries, but there is no information at hand of railroad companies having attempted either steel or malleable iron castings. Where there is an iron foundry at a shop plant, a small section is usually devoted to brass foundry work. Where there is no iron foundry the brass foundry usually occupies a section of the blacksmith shop building, and is completely separated from the remainder of the shop by a brick wall.

LIST OF FOUNDRIES AT RAILWAY SHOPS.

A gray iron foundry has been operated in connection with the Roanoke shops of the Norfolk & Western Railway for the past twenty or twenty-five years. The C., M. & St. P. Railway has long cast its own car wheels at its Milwaukee shops and in 1906 a modern car wheel foundry replaced the old one. In remodeling the Reading shops of the Philadelphia & Reading Railway a foundry was built in 1902. At Angus on the Canadian Pacific Railway there is a gray iron foundry and a car wheel foundry; and the South Louisville shops of the Louisville & Nashville Railroad include a gray iron foundry.

Wheel and gray iron foundries were operated in connection with the Altoona repair shops of the Pennsylvania Railroad previous to 1906. In that year a complete foundry plant, isolated from all other shops, was built at South Altoona. This plant at present consists of a wheel foundry, gray iron foundry, machine shop and material building, pattern shop, power house and an office building. The plot of ground on which the foundry plant is built is large enough to permit of future extensions to the present buildings and also for the addition of brass and cast steel foundries which have been considered. Foundry work for the entire system is concentrated, so far as possible, at this point and the plant is so located as to afford good shipping facilities to all parts of the system.

Plans for new shops on which construction work has been begun by the Delaware, Lackawanna & Western Railroad at Scranton, the Big Four at Beech Grove and the Grand Trunk at Battle Creek, make liberal provisions for foundry equipment.

GRAY IRON FOUNDRY BUILDING.

The construction of the foundries for gray iron castings which are already in operation and the design of those now under consideration, is in general very similar to the construction now usually followed in modern railway shop buildings, though in point of detail it is arranged for the specific class of work for which provided. The building is commonly a self supporting structure with brick walls. It is characteristic of foundries already built that they are well provided with ample natural light. A large proportion of the walls are given over to glass windows and in addition to the light so provided, that portion of the steel structure surrounding the center bay and extending above the roofs of the side bays, is equipped with glass windows. The roof of the center bay generally includes a monitor, with side window lights, extending nearly the full length of the building. At South Louisville the roof is of the same height throughout and light is admitted through the roof by saw tooth skylights.

The foundry building is usually divided into three bays, a main or central bay, from 55 to 70 feet in width, and two side bays, each about one half or little more than one half the width of the central bay.

The foundry at South Louisville varies from this general design. The main portion of the building is 318 feet long by 70 feet wide and is covered by a single span with no intermediate supporting columns. At one side is a narrow addition 20 feet wide extending the entire length of the building. Most of this additional area is included in the main floor of the foundry, but a portion of it is occupied by the cupolas, sand storage bins, ovens, etc.

As explained in connection with the provision for natural lighting, the roof trusses of the center bay are higher than those in the side bays. In the gray iron foundry at South Altoona, the height from floor to roof truss is 38 feet in the center bay and 21 feet in each of the side bays. At Angus these distances are 29 and 16 feet respectively. The plans for the foundry of the D., L. & W. at Scranton provide for a height of 35 feet in the center bay and 20 feet in each of the side bays. At South Louisville the height from floor to roof truss is 35 feet.

The lateral dimensions and area of the foundry can hardly be based on any specific unit and those foundries already in service are not enough alike in this particular to justify a definite conclusion. The foundry is not designed to meet the demands of a single shop but rather to supply an entire system. Its output is used by the locomotive department as well as by the car department, and also to some extent by the road department, so that a number of features enter into the determination of the output required.

The dimensions of several foundries, serve as records of those in railway shop service. At South Altoona, Pennsylvania Railroad, the gray iron foundry is 400 feet long by 130 feet wide; at Angus, Canadian Pacific Railway, the gray iron foundry is 342 feet by 122 feet; at Reading, Philadelphia & Reading Railroad, 564 feet by 163 feet; at South Louisville, Louisville & Nashville Railroad, 318 feet by 70 feet, and the foundry for the Delaware, Lackawanna & Western Railroad at Scranton will be 400 feet by 120 feet.

LOCATION.

As the foundry is a manufacturing department its location provides for the receipt of raw material and for the delivery of finished castings. Therefore its most convenient situation is adjacent to the avenue of distribution and communication among the shop buildings. This affords delivery of the finished material over the most direct route to the storehouse and to the various points of consumption. It is also essential that the transportation of raw material for the foundry shall not impede general yard traffic and on this account the foundry is frequently located at an extreme end of the plot occupied by the shop buildings.

It is generally considered desirable to have the foundry near the locomotive shop in order to provide for the shortest movement of the heavier locomotive castings. Castings for the car department are so much smaller that their delivery is a comparatively simple matter and they may be handled in bulk to good advantage. In view of the large amount of material for delivery to the line which is cast in the foundry an intimate communication between the storehouse and the foundry is essential.

LOCATION OF FOUNDRY AT ANGUS, C. P. RY.

At Angus, Canadian Pacific Railway, the foundry is next to the locomotive shop and is adjacent to the crane served avenue, or Midway, which traverses the shop yard. The store house is directly across the Midway from the locomotive shop and it is therefore evident that the store house is but a short distance from the foundry. The car erecting shop is adjacent to the Midway and the direct delivery of material from the foundry to this shop is very convenient. Castings are transferred in hand-car lots over the industrial tracks of the Midway.

The scrap and storage yard at one side of the foundry is served by a traveling crane of 20 tons capacity and this yard is entered by a delivery track connecting with the general yard system of tracks. Beyond the end of the foundry, opposite to the Midway, is additional storage space of large area.

The pattern shop and storage building are next to the foundry, with the crane served foundry yard between them.

LOCATION AT BEECH GROVE, BIG FOUR RY.

At the Beech Grove shops of the Big Four Railway, now under construction, the foundry is at the extreme end of the yard. One side of the foundry is served by the yard crane, and a platform, one side of which is partly under the yard crane, extends from the foundry to the store house. By this arangement there is no unnecessary handling of castings. Raw material enters one side of the foundry, and the finished castings are taken directly to their destination, or are stored on the store house platform, which is in the direct path of travel to any department. The pattern shop, although convenient to the foundry, is isolated from all other buildings for fire protection.

LOCATION AT SOUTH LOUISVILLE, L. & N. R. R.

At the South Louisville shops of the Louisville & Nashville Railroad, the foundry, with the pattern storage building near by, occupies a position at the extreme north end of the shop plant. The foundry is adjacent to a crane served storage yard to which the metal working portion of the plant is tributary. At the other end of this yard is a transfer table pit at right angles with the crane served yard. This pit traverses the plant between the locomotive shop and the car department shops and the store house is at the end of the transfer table pit away from the storage yard.

This location of the foundry was selected in pursuance of a plan to enter all raw material at the ends of the plant and work it toward the center where locomotives and cars arrive on the transfer table ready for delivery. While the foundry is not close to the store house and other points of destination for finished castings, it is in direct communication with them by means of the thoroughfare provided by the crane served yard and the transfer table pit.

CRANE SERVICE.

Crane service is an important factor in the operation of the up to date foundry. The main bay is served by one or more traveling cranes operated electrically and one or more of the side bays are sometimes served by a traveling hoist, usually controlled by hand from the floor. The traveling cranes are supplemented by portable jib cranes, so supported that they may be readily transported from one location to another as required. These are operated electrically or by hand. Where operated electrically plug connections are conveniently installed to provide for the delivery of current.

The crane of largest capacity in railway shop foundry service, of which information is at hand is in the South Altoona foundry of the Pennsylvania Railroad. This foundry is supplied with an unusually generous crane equipment which is worthy of especial mention.

The center bay of the foundry is served by a crane of 25 tons capacity and two cranes of 12½ tons capacity each. All of these cranes operate on the same runways with the heavier crane between the other two. The runways extend 280 feet beyond the walls of the building at each end. The ends of the building are so arranged that these traveling cranes may run out on the extended runways and thus serve outdoor storage spaces where flasks, heavy castings, etc., are stored, as well as the shipping tracks. The brick walls, except for a door 12 feet wide, extend up to the height of the crane runways and above them the space is closed by a lifting door which extends the entire width of the bay. This door is made of corrugated steel, and is arranged to swing inward so as

to allow the cranes to pass beneath it. It is operated by a mechanism driven by an electric motor. In addition to these cranes serving the center, there are a number of portable 5-ton jib cranes attached to the columns along the side of the bay.

The design of the building provides for each side bay to be served by an electric traveling hoist of 5 tons capacity operating on runways carried by the supporting columns of the steel structure.

At Angus the center bay is served by a traveling crane of 10 tons capacity, and a space, in the side bay, about 50 feet in length, devoted to the core room, is served by a 5-ton traveling hoist controlled by hand from the floor.

At Reading, the central bay is served by a crane of 10-tons capacity, while a portion of each side bay is served by a traveling air hoist of 1-ton capacity.

The floor of the foundry at South Louisville, is served by a crane of 20 tons capacity.

Plans of the foundry at Scranton provide for the center bay to be served by a crane of 15 tons capacity and one of 5 tons capacity operating on the same runways. The runways will be carried through one end of the building in order that the cranes may serve a casting platform beyond the end of the foundry.

DISPOSITION OF WORK.

The entire area of the main or central bay is used as a moulding floor, with the exception, sometimes, of a portion at one end which is reserved for cleaning the heavier castings that require the service of the crane. The side bays usually contain the cleaning room for lighter castings, foreman's office, small pattern storage space, fan rooms, floor for furnaces, core ovens, core room, cupolas, moulding machines, etc., and the lavatory usually occupies a portion of one side bay.

INDUSTRIAL TRACKS.

The main bay is generally served by a system of narrow gauge industrial tracks which completely encircles the floor and frequently includes a track which traverses the bay immediately opposite the cupolas. In the corners of the building and at the juncture of two tracks either curves or turntables may be installed, however, the turntable meets with greater favor as occupying less space and proving more satisfactory. A similar industrial system serves the immediate storage yard and provides for handling pig iron, scrap, coke, etc.

CHARGING FLOOR.

The charging floor is usually reached by an electric or hydraulic elevator, the latter receiving greater favor. At Angus delivery is made to the charging floor by the crane serving the storage yard.

The charging platform, as a general thing, is served by narrow gauge tracks of the same gauge as the surface industrial system, for delivering push cars to the cupola charging door and to the temporary storage spaces. It is common practice to store on the charging floor sufficient material to operate the cupolas for at least one day, in case of emergency. A narrow gauge track scale is introduced in the track system on the charging floor between the point of delivery and the charging door.

At Reading there is a transfer table on the charging floor which serves several spur tracks. Several loaded cars may be stored temporarily on these tracks and any one of them taken out individually.

CUPOLAS.

The railway shop foundry is usually equipped with two cupolas of about 18 or 20 tons capacity each. They are generally so situated as to be charged from the same charging floor. Cupolas are placed in one of the side bays and in such relation to the center bay that they may be tapped in the main floor within reach of the traveling cranes.

PATTERN SHOP.

Pattern storage is usually provided for in a building of fire proof or slow burning construction, located in close proximity to the foundry. This storage building is either isolated or is in connection with a pattern shop from which it is separated by a fire wall having door-ways that are equipped with sliding doors which are normally kept closed and which close automatically in the event of the temperature in the shop rising sufficiently to melt the fuse controlling the operating mechanism.

PATTERN SHOP AT ANGUS, CANADIAN PACIFIC RY.

At Angus the pattern shop is in a two story building occupying a ground space 82 feet by 50 feet. The building is of brick and the roof is supported by wooden columes dividing the floor space into three bays. Patterns are stored in a fire proof building of concrete and steel construction, 150 feet long by 100 feet wide. The roof is supported by 20 inch I beams at 15 foot centers, carried on the side walls and resting on a row of steel columns through the center of the building.

PATTERN SHOP AT SOUTH ALTOONA, PENNSYLVANIA R. R.

At South Altoona the pattern shop and storage room are in the same building but in two distinct sections. The building is of brick, 386 feet long by 91 feet wide. The section occupied by the pattern shop is one story high (16 feet from the floor to the underside of the roof trusses) and 193 feet long, while the pattern storage section is 180 feet long and three stories high.

The frame work of the section occupied by the pattern shop is of steel. Ample natural light is provided by large window areas in the walls and by glass in the skylight. Work benches are placed along the side walls and machines are grouped in the middle of the shop.

The shop is lighted by 32 enclosed arcs, and each work bench is provided with a 16-candle power incandescent light.

The pattern storage section is separated from the pattern shop by a 12 foot hallway, which contains the elevators and stairs. The framework of this part of the building is of heavy timber construction. It is divided by brick walls into three sections and the doors between these sections are of steel and normally closed. This part of the building is equipped with a sprinkler service, which is operated by valves placed outside of the building. Openings are made in the side walls at each floor to prevent the floor from becoming overloaded in case one of the rooms is flooded. Each section is provided also with fire extinguishers and fire hose.

All patterns except the very large ones are stored on shelves, and so arranged that they may be located readily by means of a card index system, and can easily be returned to their proper places on the shelves.

The storage section of the building is lighted by incandescent lights.

A narrow gauge track extends from this department to the foundries to facilitate the delivery and return of patterns.

WHEEL FOUNDRY.

The most notable examples of wheel foundries operated by railways are those of the Canadian Pacific at Angus, the Chicago, Milwaukee & St. Paul at Milwaukee and the Pennsylvania at South Altoona. At these points foundry practice in making cast iron car wheels has attained a high degree of development. These three foundries are operated much on the same principle and the general features in the design of the buildings are similar, though they may vary to some extent in point of detail. In all of them the straight floor system of moulding is used; each floor is provided with an overhead trolley hoist which travels the length of the floor, and a number of labor saving devices have been introduced.

At each of these foundries the building is a steel structure with brick walls. The building contains a single large working area on which the moulding floors are arranged and an addition along one side providing for the auxiliary departments, cupola, charging floor, core ovens, blower room, etc. Annealing furnaces, served by traveling cranes occupy positions at one or both ends and a shipping platform is arranged at one end or along one side to suit local conditions.

WHEEL FOUNDRY AT ANGUS, CANADIAN PACIFIC RY.

The wheel foundry at Angus, Canadian Pacific Railway, is the most likely illustration of the location of a wheel foundry as a component part of a railway shop plant. It is located where ample space is available for the storage of pig iron, scrap wheels, sand, etc., and where the foundry is convenient for the direct delivery of wheels to the truck shop. The wheel foundry is at one edge of the area occupied by shop buildings where the delivery of material offers no impediment to general yard traffic and between the wheel foundry and the truck shop is a large area for the temporary storage of wheels. The provision for this storage space is worthy of more than mere passing mention for the experience of the Angus shops indicates that the absence of such a storage yard in close proximity to the truck shop would have been a serious handicap.

The wheel foundry is 187 feet long by 107 feet wide, the area within these dimensions including the moulding floors and the annealing pits. An additional portion of the building 90 feet long by 27 feet wide includes two cupolas and the various auxiliary features. The annealing pits are at one end of the foundry and the shipping platform is at this end immediately outside of the building. The floor above the annealing furnaces is 4 feet above the main floor of the foundry and on the same level as the shipping platform. The annealing furnaces are served by a single crane spanning the entire space occupied by them. The foundry has a capacity of 300 wheels per day. The wheels are poured on 15 floors of 20 wheels each.

WHEEL FOUNDRY AT MILWAUUEE, C., M. & ST. P. RY.

The present wheel foundry at Milwaukee, Chicago, Milwaukee & St. Paul Railway, is modern in every particular and replaced an old wheel foundry which operated seven circular floors, pouring 26 wheels to the floor, with a total daily capacity of 182 wheels. The new foundry has a capacity of 600 wheels per day. The entire building is 364 feet long with a maximum width of 159 feet, this width including a lean-to 31 feet wide, which contains the cupolas, wheel stacking room, core ovens, etc. A brick curtain wall separates the core room and cupola house from the remainder of the foundry and the blower room which is on a level with the cupola platforms, is entirely enclosed and is provided with a concrete floor. The foundry is divided into 24 floors of 24 wheels each and this portion occupies a space 288 feet by 128 feet. The cupola house is 96 feet 5 inches by 31 feet. The annealing furnaces occupy a space approximately 125 feet by 40 feet 8 inches. The pits are spaced 6 feet between centers. There are 144 pits, each 36 inches in diameter and having a capacity of 16 wheels. The pits are of steel plate, lined with fire brick and having a double layer in the bottom. The annealing floor is 4 feet 3 inches above the foundry floor and has a concrete retaining wall.

The cupolas are of the manufacturers standard type, 96 inches in diameter and lined to a diameter of 78 inches. Each has a wind box 118 inches in diameter and the height from the floor to the top of the stack is 50 feet. The cupolas are so located that each one can conveniently serve 12 of the floors. The total melt of the two cupolas is about 220 tons, or at the rate of 20 tons per hour each. They are provided with operator's platforms, which likewise serve as platforms for the tapper.

The cupolas practically divide the foundry into halves and each has a capacity to serve 12 floors. The ladle track is in front of the cupolas, while the hot wheel track is on the opposite side, with the floors arranged transversely between them. The trolley hoists serving the floors are operated by compressed air. The cylinder and valves for the hoist are supported on the wall at the side of the foundry opposite to the cupolas where they are out of the way of dust and dirt from the floors.

Two trains of hot metal cars operate on a narrow gauge track, each traversing half the length of the foundry. Each train is made up of 4 cars and is moved by a rope haulage system operated by an electric motor, controlled by the operator in charge of the receiving ladle. Each car will hold two ladles of 1,000 lbs. capacity each. One loaded ladle is placed at one end of the car, leaving room for an empty ladle at the other end.

The cars are so spaced as to serve four floors at the same time. The ladle is transferred form the car to any desired point over the floor by the trolley hoist where the metal is poured and the ladle returned to the car.

When the wheel is sufficiently cool it is shaken out and gripped on the edge by tongs depending from the trolley hoist. When lifted it is suspended in a vertical position and the loose sand which does not fall away when the wheel is raised can be knocked off with a sledge. This edge grip places the wheel in position to be deposited by the hoist on the buggies which operate over the hot wheel tracks along the ends of the floors. Methods in more common use for handling hot wheels with the hoist provide for gripping the wheel at three points and lifting it to a horizontal position. Hot sand is then shoveled from the upper side of the wheel and rapped from the bottom.

The hot wheel buggies are operated in trains of four cars each over two tracks. The buggies have a capacity of one wheel each and are operated by a rope haulage system, similar to that operating the hot ladle buggies. Their movement is controlled by an operator on a stationary platform attached to the side of the building and overlooking the tracks.

The buggies convey the wheels to the end of the foundry at which the annealing pits are located. The pits are served by three special 1 ton electric traveling cranes. Each crane serves two rows of pits and is equipped with two 1,000-lb. hoists from which center bore tongs are suspended. Wheels are lifted from the buggies by these tongs and deposited in the pits to be annealed.

Connection between the hot ladle tracks and the hot wheel tracks is made by means of a narrow gauge track outside of the building equipped with turn tables at the points of juncture. The same track system provides for connection to the storage yard. The storage yard is well provided with a narrow gauge industrial track for the delivery of material.

Before the wheels are lifted from the buggies by the pitting cranes, the heads are knocked off of the wheels and they are conveyed in buggies over these industrial tracks to the storage yard, where they are used for making up charges for the cupolas.

The cupola charging floor is served by two pneumatic elevators of 4 tons capacity each, having 20 inch cylinders with 11 foot stroke and a lift of 22 feet. Each elevator has a steel cage 6 by 8 feet and is provided with tracks on which coke, pig iron and scrap buggies are carried from the ground floor to the charging room. In addition to two main tracks there are four storage tracks on the charging floor on which coke and metal can be stored while the heat is in progress. Turn tables are conveniently located so that both cupolas are amply provided for. In addition to the pneumatic elevators the floor can be reached by a steel staircase from the charging department.

Metal from the cupolas is tapped into 10-ton receiving ladles which are tilted by 13 horse power electric motors operated from an adjoining platform by the operator who controls the hot ladle cars. The receiving ladles are equipped with skimming spouts and are provided with an emergency hand power mechanism beneath the operator's platform. The operator is shielded by a steel protecting plate.

The three core ovens are served by a small transfer table which provides for shifting and distributing the special buggies on which the cores are run into the ovens. These buggies are really portable shelves on which they remain while in the ovens. Cores are delivered to the various floors by being placed on platforms and carried to their destinations by the hot ladle cars.

WHEEL FOUNDRY AT SOUTH ALTOONA, PENNSYLVANIA R. R.

The wheel foundry at South Altoona has a capacity of 900 wheels per day. The interior is a single room 600 feet long by 186 feet wide, with no divisions between the moulding floors, annealing pits and cleaning rooms, but with a space 410 feet by 60 feet enclosed for the cupola, sand storage, core and wash rooms. These rooms have brick partitions. The side walls include large areas of glass and the monitors, which extend across each section of the building, have skylights extending their entire length, with the result that ample natural light is provided. The monitors are wide and high and equipped with swinging sash, thus affording good ventilation.

With the exception of the cleaning room and annealing pits at each end of the building, the foundry is divided into three working divisions. Each division includes 12 moulding floors of 25 wheels each and is served by two 86 inch cupolas. Each cupola has a capacity of 12 tons per hour.

The core room is equipped with two sets of three ovens. A coke furnace beneath each oven is fired from a pit under the core room floor. It has two flues which deliver the gases to the rear corners of the oven, where they rise, pass up through the shelves at the back to the top and then return to the floor and to the outlet at the lower front corner. In the center of each oven is a vertical shaft with collars which support seven shelves of 3-16 inch perforated tank steel 10 feet 6 inches in diameter and spaced 13⅛ inches apart. The shelves are mounted on ball bearings and revolve independently.

Between the two sets of ovens is a sand bin 40 feet by 28 feet 10 inches, having a capacity of 550 tons, with wooden walls 2½ inches thick, supported by an outside steel frame work of 12 inch I beams.

Two sets of annealing pits occupy positions at opposite ends of the foundry. The space covered by the pits at each end is approximately 140 feet by 41 feet. The pits are enclosed by masonry retaining walls which rise about 8 feet above the foundry floor. The walls thus form a large pit which contains the annealing furnaces or cylinders. The bottom of this pit is covered with 6 inches of concrete, sloping toward one corner for drainage. The furnaces are arranged in four rows, 25 in each row, and are carried on concrete benches or platforms 18 inches above the bottom of the pit. The rows are arranged on 11 foot centers and the furnaces are 18 inches apart. Each furnace has a capacity of 25 wheels. It is made of ⅜ inch sheet steel, is 16 feet deep, and is lined with fire brick 6 inches thick. The space between the supporting platforms is filled with coarse broken stone. Between the furnaces is a layer of fine stone and above this the space is filled with green and burned sand extending to the top of the wall.

Each lot of annealing furnaces is served by a traveling crane having a span of 44 feet and a capacity of 4,000 lbs. This crane has four independent hoists, spaced 11 feet apart, each driven by a 7½ horse power motor, controlled separately from the cab. The crane is operated by a 10 horse power motor and traverses at a speed of 500 feet per minute. The hoists operate at speeds up to 100 feet per minute. There is a spare hoist on the bridge and an extra motor for traversing which can be connected quickly in case of accident to the regular motors.

A space 11 feet wide is devoted to each moulding floor and a row of 25 flasks are set on a pair of rails spaced 24 inches apart. The trolley hoists serving the floors are operated electrically and both the traversing and hoisting operations are controlled by one handle which can be reached conveniently from the floor. They have several hoisting speeds, ranging from 16 to 75 feet per minute and a range of traversing speeds up to 400 feet per minute. The nominal capacity is a lift of 1,000 lbs., at 60 feet per minute.

Each pair of cupolas discharges into a delivery ladle of 14,000 lbs. capacity, consisting of a brick lined steel shell mounted on trunnions. The ladles are tilted by a chain which passes over a sheave on the end of the trunnion shaft and is operated by an hydraulic cylinder located underneath the bed plate and controlled by a valve conveniently placed. The delivery ladle is so arranged that the flow from the cupola does not have to be stopped while the ladle is being tilted to supply the pouring ladles.

The storage yard is well provided with a narrow gauge industrial system for the delivery of material. The charging floor is served by an hydraulic elevator of 5 tons capacity.

FOUNDRY SYSTEMS AT ANGUS, CANADIAN PACIFIC RY.

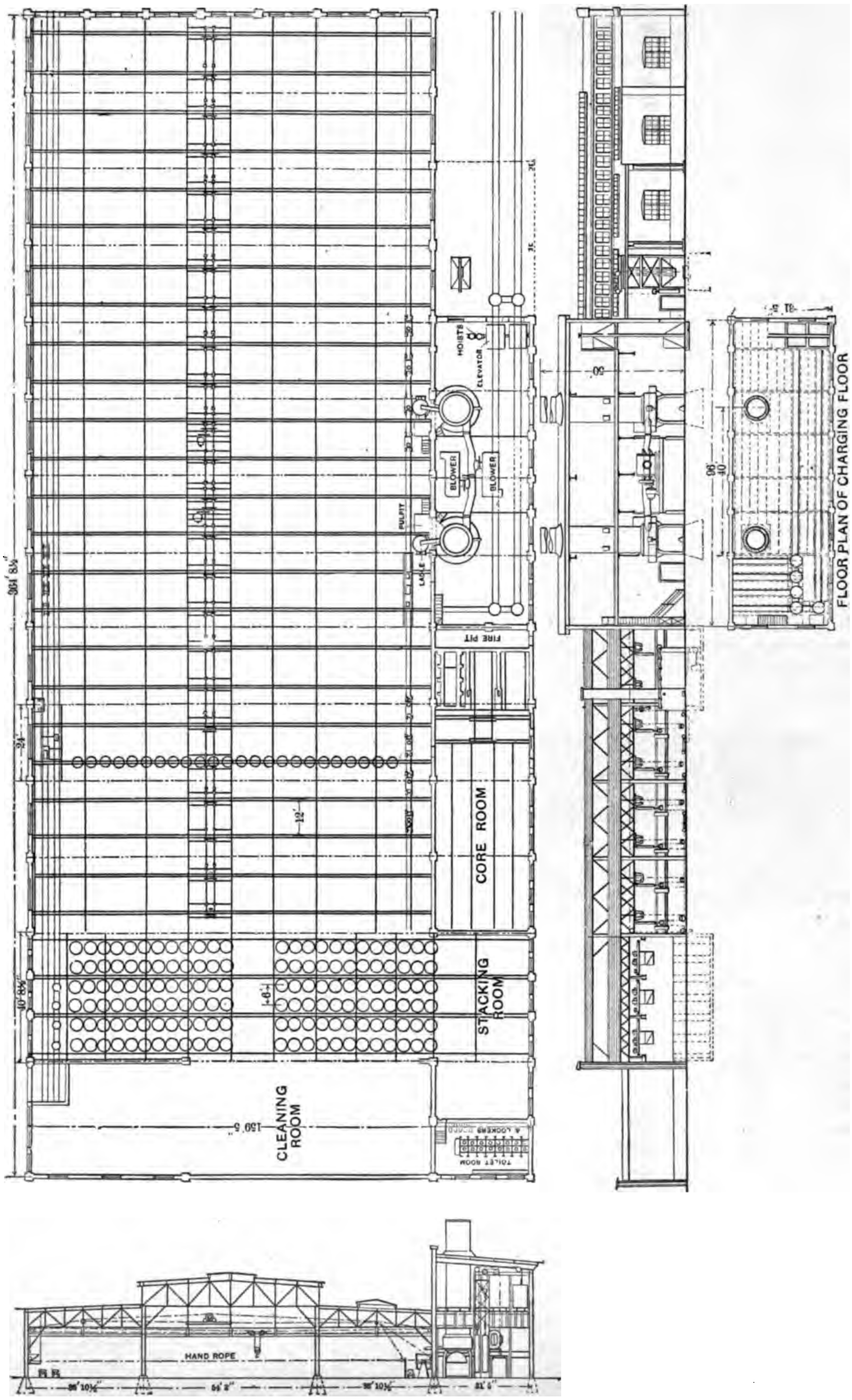
A brief outline of the operation of the foundries at Angus is interesting as referring to the practices of a railway shop plant which has successfully operated both wheel and gray iron foundries for several years. The two foundries, gray iron and wheel, turn out the majority of gray iron castings for the entire system and the total wheel supply for the road. They are treated very much as the railroad company would treat an outside concern, so that the same service, or better, may be exacted from them as would be expected from outside foundries. They are operated by the car department and the master car builder is directly responsible for them. At the same time the total intake of raw material and the output of finished castings are considered as the property of the general storekeeper and in order that accurate account may be kept and reported to this official, the intake and output are checked and weighed by employees of the store department.

Material passing through the gray iron foundry is taken care of by two foundry checkers and one foundry clerk, whose offices are located in the scale room through which all material must pass on its way to the cupolas, so that nothing goes into the cupolas without first crossing the scales and being correctly weighed by the clerk of the stores department. These weights are posted in a book kept for the purpose and the total cost covering intake of the foundry is made up from these records of material used. All material required for the operation of the foundry is so recorded and is issued without the usual shop form. This includes material delivered to the cupolas, such as pig iron of various brands, broken wheels, scrap, coke, manganese, etc., as well as material used in the foundry proper such as sand, facings, flour, hay, etc.

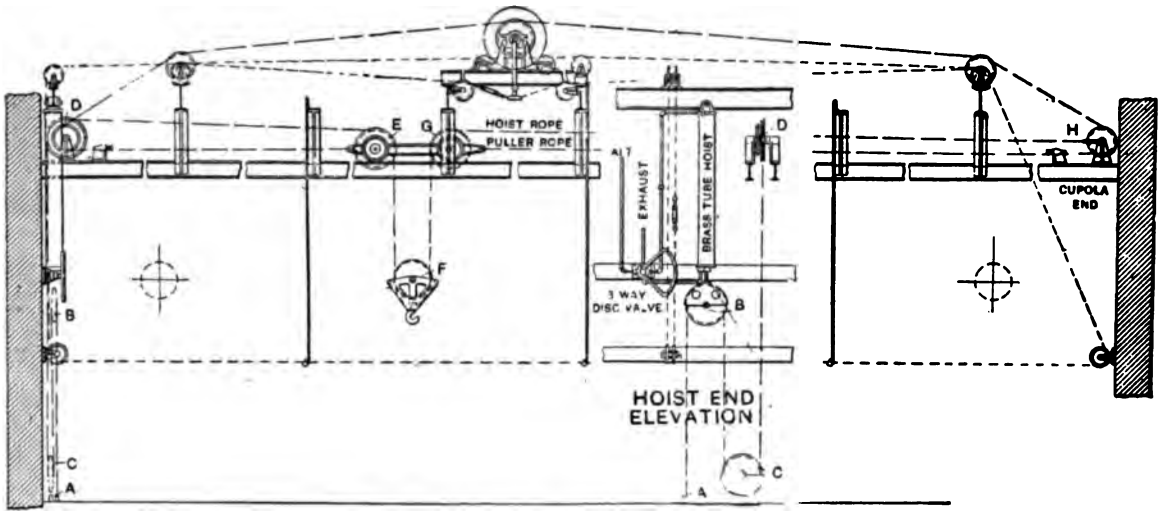
As it would naturally be an inadvisable proposition to deliver castings from the foundry to the store house and then rehandle them to the several shops, the foundry is considered much in the light of a sub-store house, or petty store, as far as deliveries are concerned. Therefore all castings for the several departments are loaded in lorry loads of about two tons each, classified according to the department to which the load is to be delivered in order that material for different departments will not become confused and the castings are delivered direct to the shop in which they will be assembled or machined. Line shipments, however, are sent to the store house where they are loaded into cars and forwarded to their several destinations.

The output, allowing for shrinkage, is always a check on the intake, yet, in order that correct record may be arrived at, all castings made in the gray iron foundry when cleaned and ready for delivery, are checked as to pattern numbers, weighed, and as each load is checked on the scale the list of various items making up the load is signed by the foundry checker (who retains a copy of the same) and handed back to the representative of the foundry foreman as his authority for delivery.

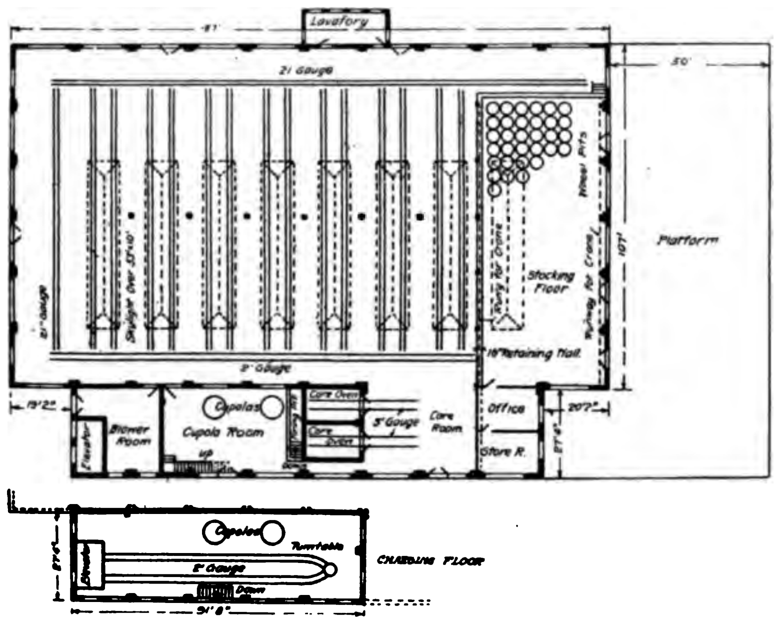
The wheel foundry is handled on precisely the same line as that outlined for the gray iron foundry, except that wheels for line shipments are not delivered to the store house, but, are loaded from the foundry platform to prevent any unnecessary handling. All wheels are charged at the same price per 100 lbs., as are ordinary castings with the exception of cylinders and wheel centers. The total cost is arrived at by adding pay rolls to value of material used, plus shop expense charges.



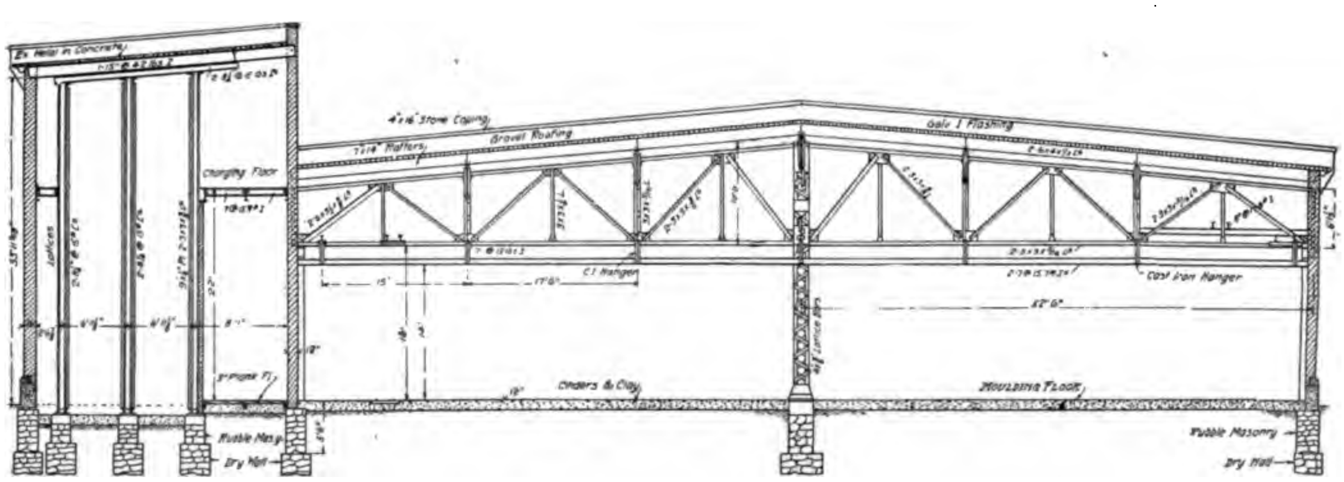
PLAN, END AND SIDE ELEVATION OF WHEEL FOUNDRY AT MILWAUKEE, WIS., C. M. & ST. P. Ry.



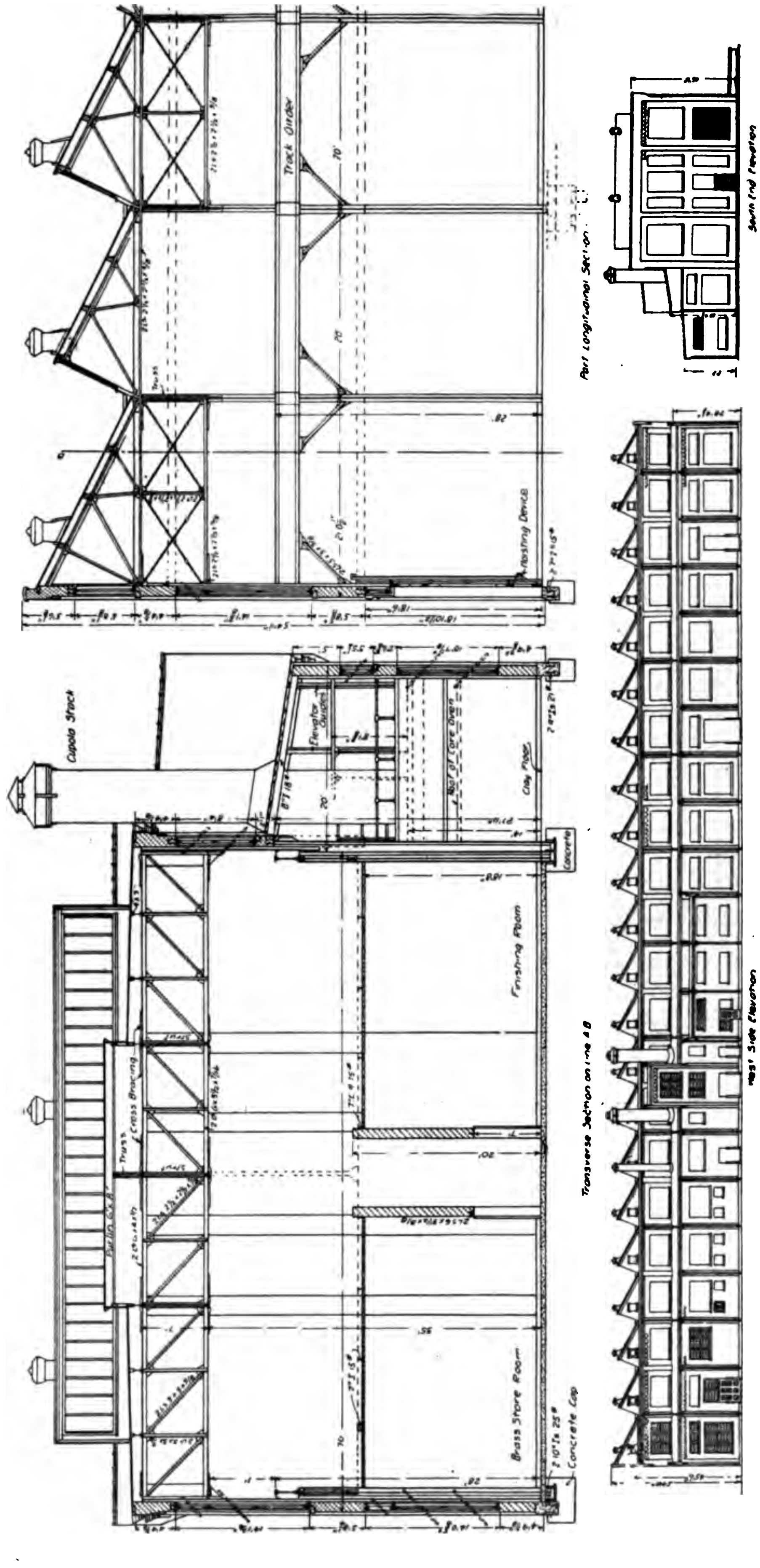
DETAILS OF FLOOR, TROLLEY HOIST MECHANISM IN WHEEL FOUNDRY AT MILWAUKEE, WIS., C. M. & ST. P. RY.



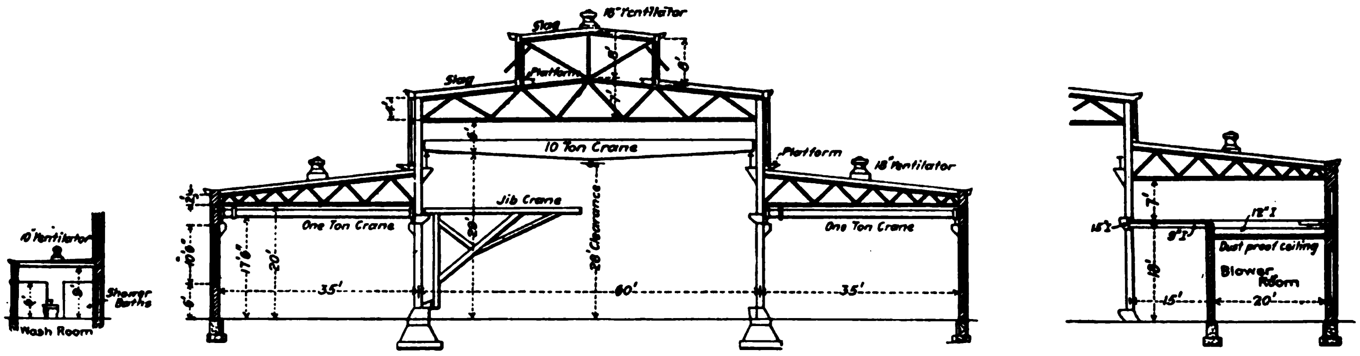
PLAN OF WHEEL FOUNDRY AT ANGUS, C. P. RY.



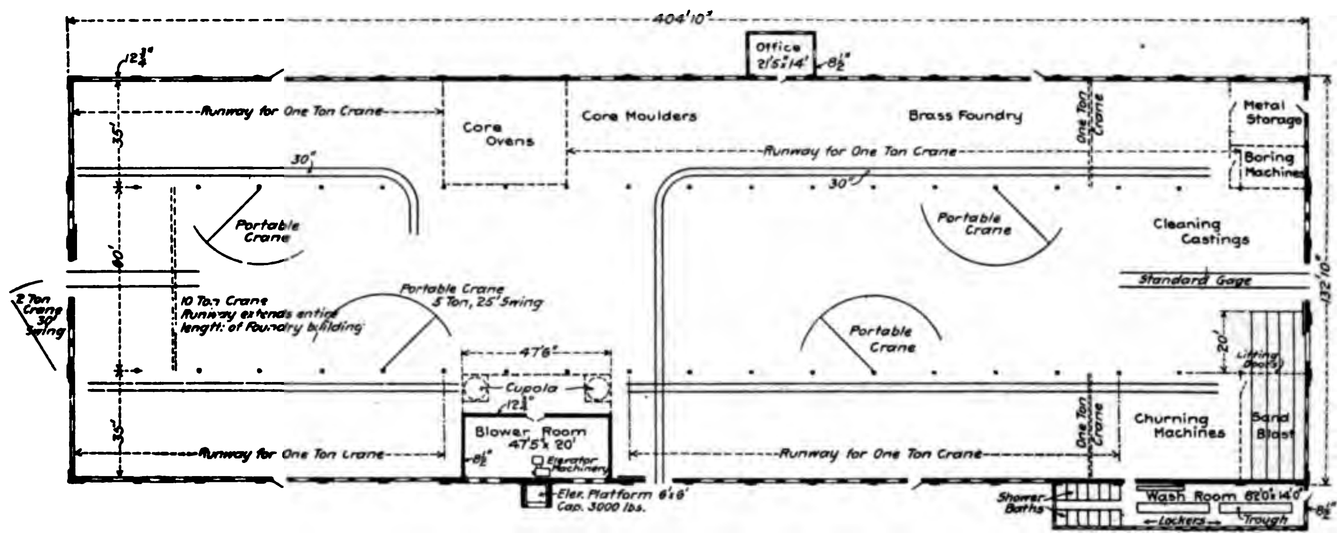
CROSS SECTION OF WHEEL FOUNDRY AT ANGUS, C. P. RY.



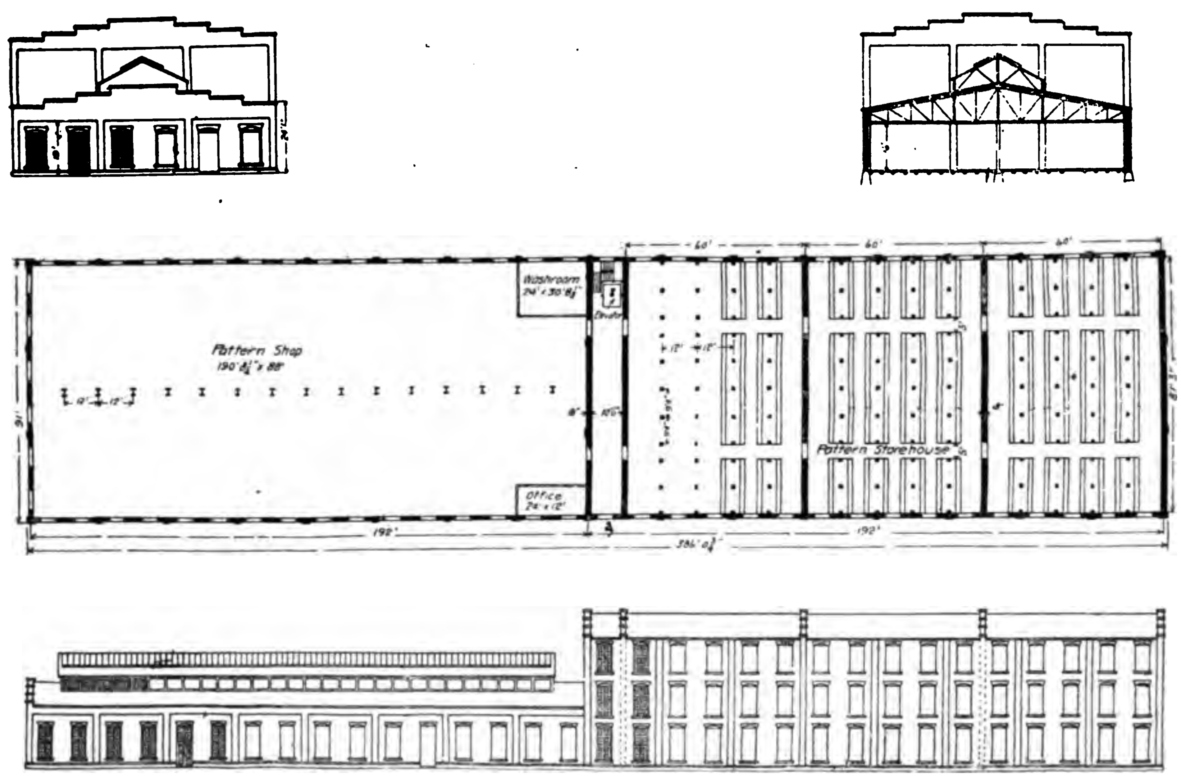
SECTIONS AND ELEVATIONS OF GRAY IRON FOUNDRY AT SOUTH LOUISVILLE, KY., L. & N. R. R.



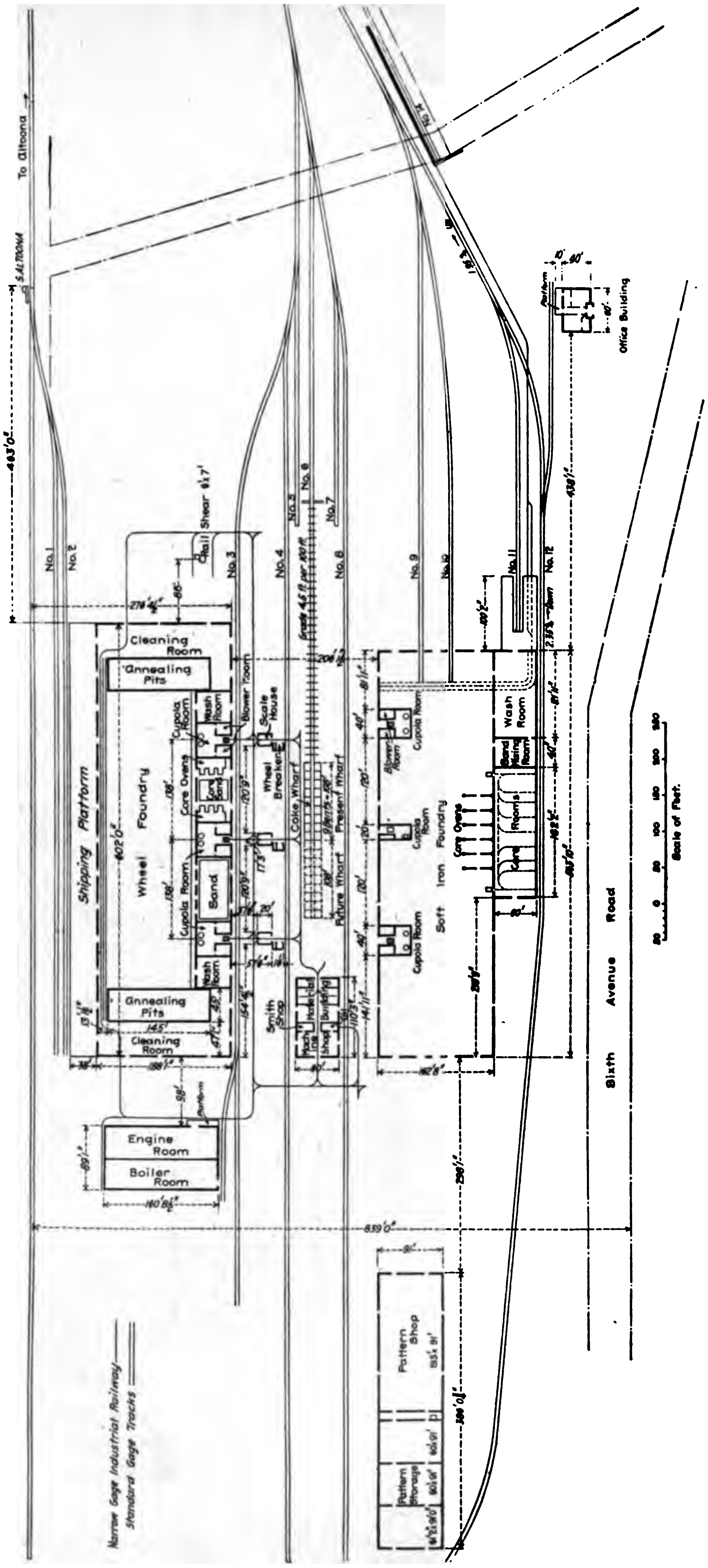
CROSS SECTIONS OF FOUNDRY AT READING, PA., P. & R. R. R.



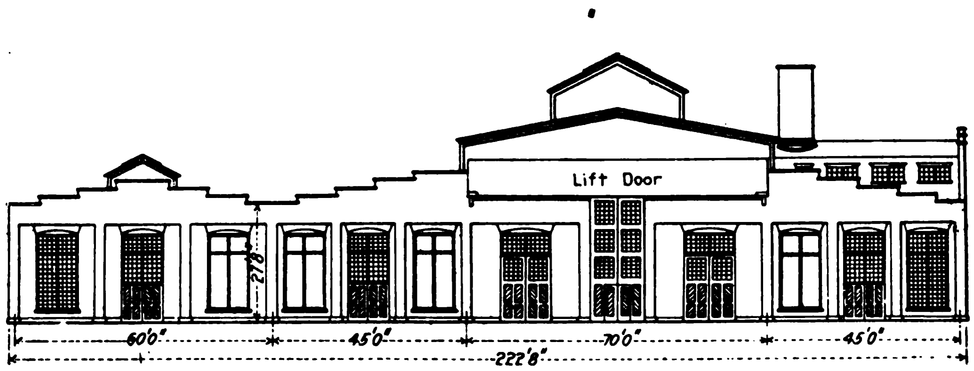
PLAN OF FOUNDRY AT READING, PA., P. & R. R. R.



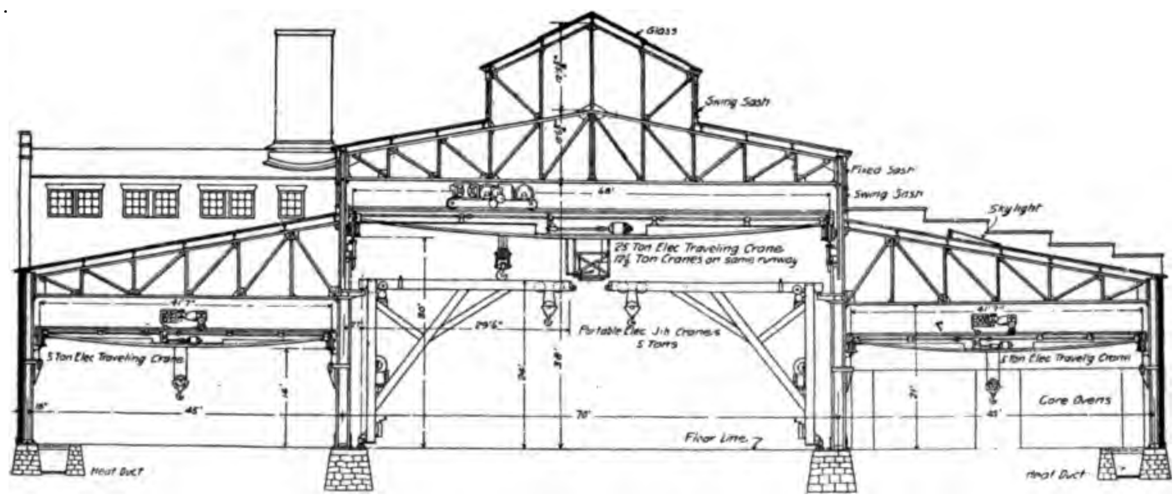
PLAN, ELEVATIONS AND SECTIONS OF PATTERN SHOP AND STORAGE BLDG. AT S. ALTOONA, PA., P. R. R.



GENERAL LAYOUT OF FOUNDRIES AT SOUTH ALTOONA, PA., P. R. R.



END ELEVATION OF GRAY IRON FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



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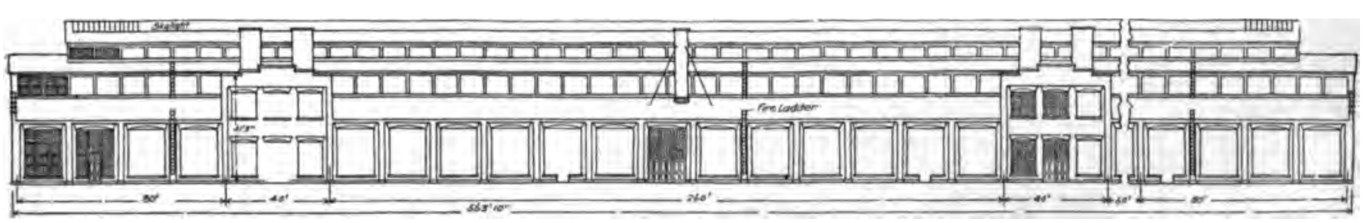
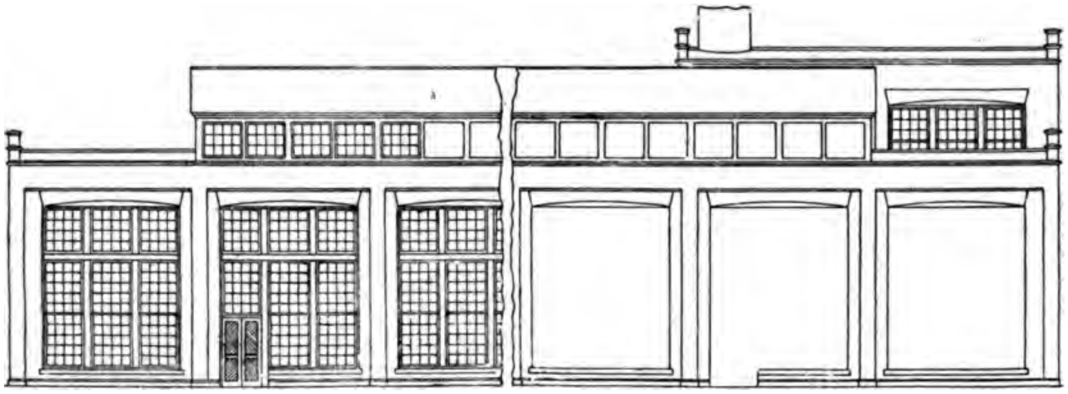
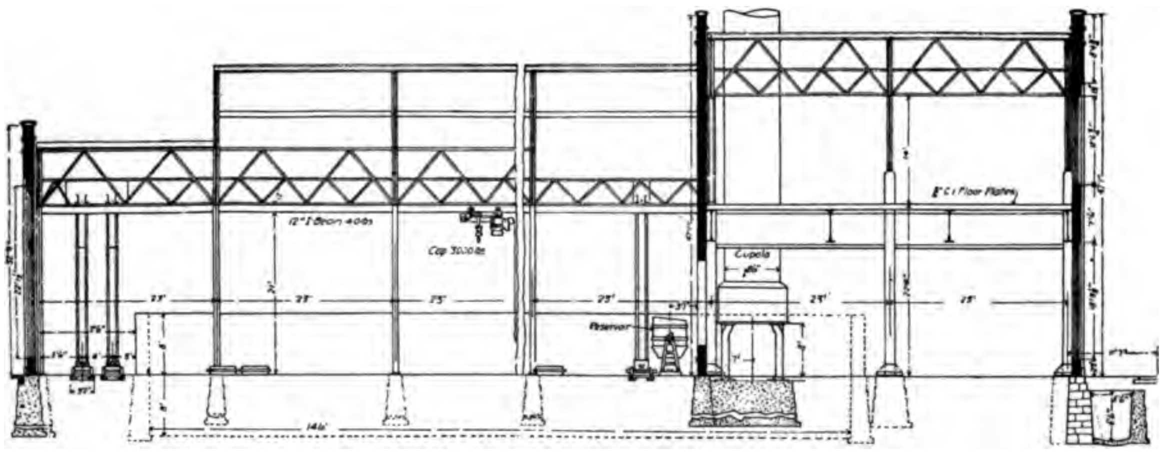


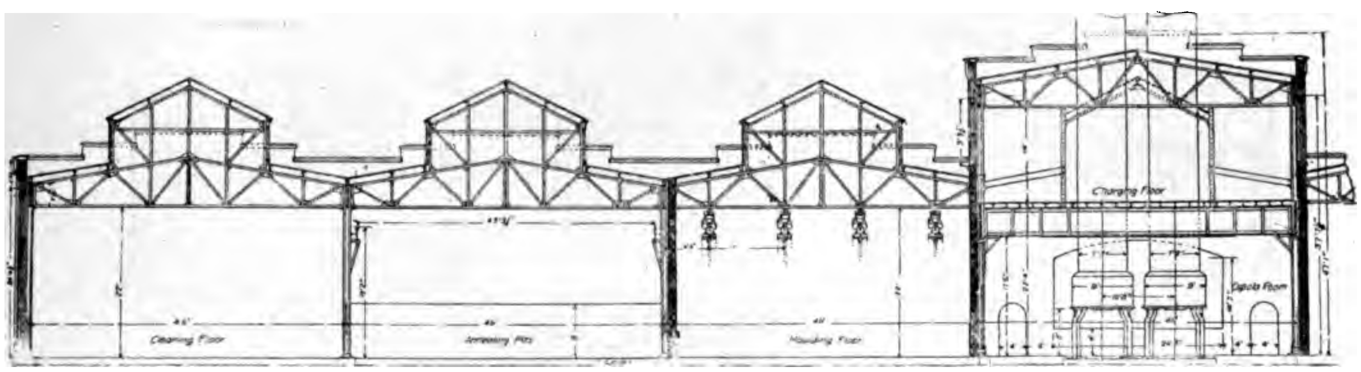
SIDE ELEVATION OF GRAY IRON FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



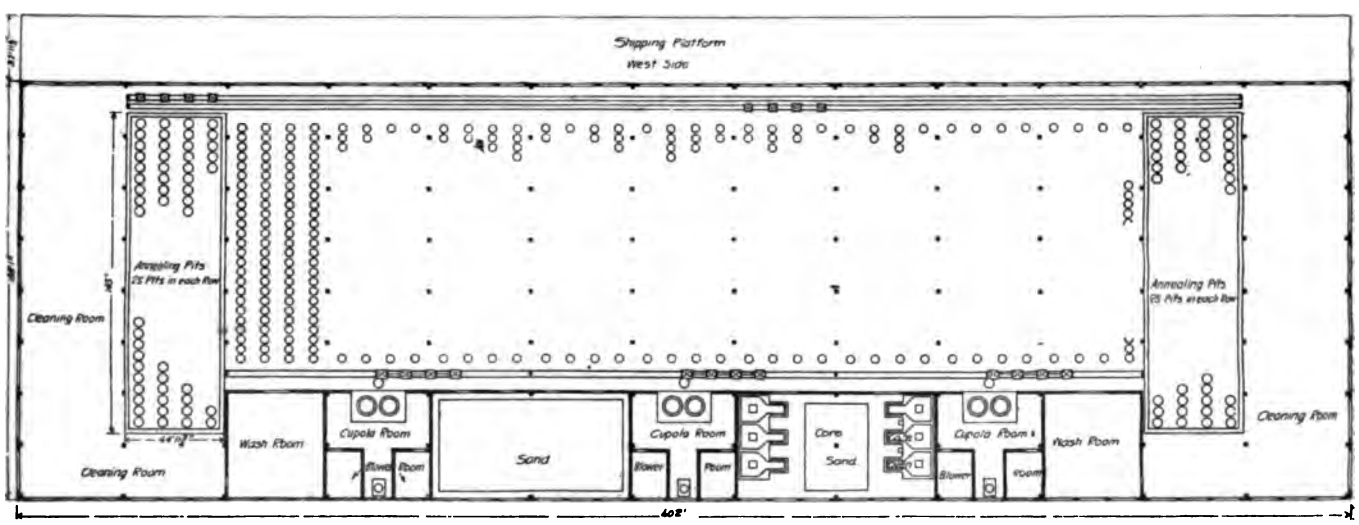
END ELEVATION OF WHEEL FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



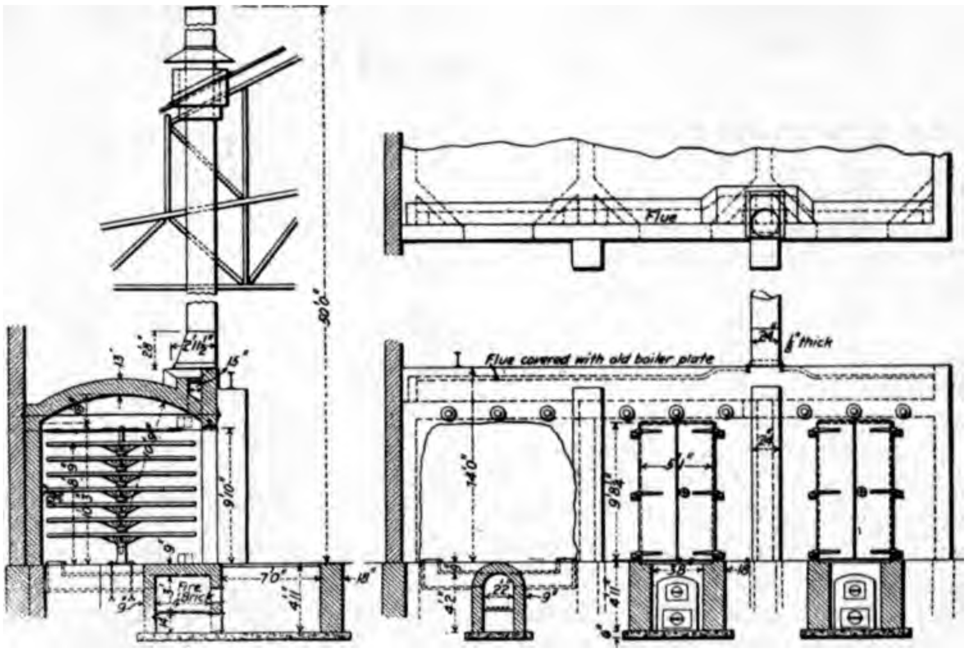
CROSS SECTION OF WHEEL FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



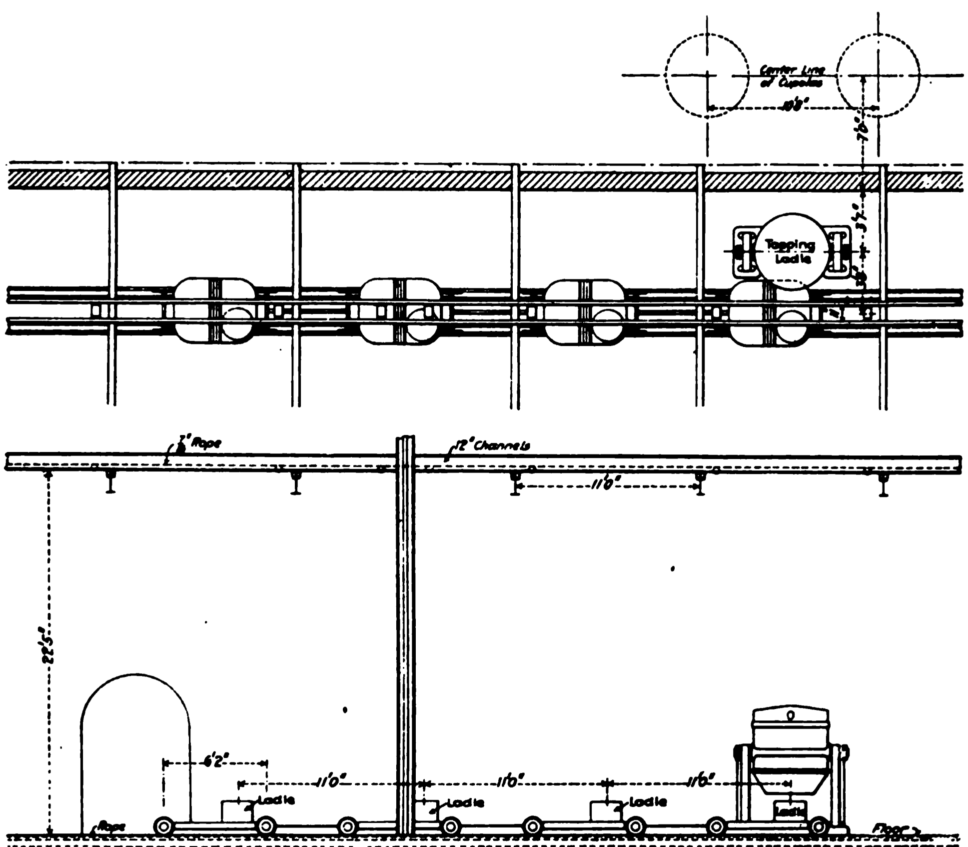
PARTIAL LONGITUDINAL SECTION OF WHEEL FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



PLAN OF WHEEL FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



DETAILS OF CORE OVENS IN WHEEL FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.



ARRANGEMENT OF HOT LADLE CARS IN FRONT OF CUPOLA IN WHEEL FOUNDRY AT SOUTH ALTOONA, PA., P. R. R.

Railway Shop Up To Date

Chapter X

POWER PLANT

THE power plant of the modern railway shop has been developed into one of its most important features. Until about fifteen years ago power for a railway shop was generated in several boiler and engine rooms situated at different points about the shop plant. At some shops a single boiler house provided steam for several engines situated at different points. The latter were usually located in annexes to the principal shop buildings and belted to line shafts At a number of shops built within a later period this same practice was followed in providing for the distribution of power. It is only within comparatively recent years that a single power house has been installed as the center of generation and distribution of all power for a railway shop plant.

The introduction of electrical equipment into railway shop operation has brought about the concentration of all power generating apparatus in a single building. It is now the universal practice to generate power at one central point and distribute electrical power to the various points of consumption. A plant capable of developing all power necessary for the operation of the entire shop is located as near as possible to the theoretical center of distribution. All power for driving machines and for providing artificial light, is led from this central plant to the various buildings by electric current.

The railway shop power plant of to-day exemplifies a state of development representative of the best engineering skill and experience. The character of the building in which the power generating apparatus is housed indicates careful design, and illustrates a practical provision for the peculiar requirements which the plant must meet. The details of the steam, mechanical and electrical apparatus are worked out to advantage and it may be said that the building with its equipment and machinery is but a complete machine for the generation of power and for the delivery of power to the transmission lines.

LOCATION.

The location of the power house should be as near as possible to the center of distribution, determined by the power consumption of the machinery in the various shop buildings. The point of greatest consumption is the locomotive machine shop and next in order is the planing mill.

The refuse produced by the planing mill is commonly delivered to the power house where it is used as fuel for at least a portion of the boiler equipment. In view of the large bulk of the shavings, etc., its economical delivery represents a considerable factor in expense. By situating the power house near the planing mill, refuse from the lumber passing through the machines is delivered by a system of air ducts direct from the floor of the mill to a vault in the power house and from the vault the shavings are led to the grates beneath the boilers as required.

BUILDING.

It is generally considered that architectural embellishment is out of place in connection with any of the buildings of a railway shop plant. The power house is made to conform to the general architectural scheme of the other buildings, yet it is usually more attractive and pleasing in its appearance. Being a comparatively small building and at the same time a very prominent one, additional care in improving its appearance does not seem out of place.

The power house is usually a rectangular building, and almost square. The material is generally the same as that of the other buildings of the plant and is most commonly brick. The power house at the Elizabethport shops of the Central Railroad of New Jersey is of concrete and in keeping with the other shop buildings at that point.

The building is usually divided longitudinally by a wall extending the full length. Occasionally this dividing wall is built transversely. This provides separate rooms for the boilers and engines.

The roof is generally supported by steel trusses, resting on the side walls, which are sometimes reinforced by pilasters, but the trusses are occasionally supported by independent steel columns tied to the walls for stability.

The roof usually slopes outward from the dividing wall to the exterior side walls. This is reversed at the Milwaukee power house of the C., M. & St. P. Railway where the roof slopes inward toward the dividing wall.

The modern power house is well lighted, a large proportion of the walls being given to the windows. Ventilation is provided for by a monitor over the roof of each room.

The height of floor above grade varies and seems to follow no general rule. The more common arrangement is with the floor of the boiler room on a level with the ground and the floor of the engine room several feet higher. In some cases both are on the ground level and occasionally both floors are on the same level and elevated above the ground.

It is now very common practice to provide a basement beneath the engine room to accommodate auxiliary apparatus, exhaust piping, etc., and in a few instances live steam pipes are carried in the basement.

The provision of a basement beneath the boiler room depends on the arrangement of the coal and ash handling equipment. In some plants each is delivered to

a conveyor system beneath the floor and sometimes a commodious tunnel is provided for this purpose.

The dimensions of power houses naturally vary at different points and it is interesting to note the sizes of several prominent ones. The power house at Topeka, A., T. & S. F., Ry., is 176 feet by 57 feet 4½ inches; at Du Bois, B., R. & P. Ry., 90 feet by 60 feet; at Angus, C. P. Ry., 160 feet by 100 feet; at Danville, C. & E. I. R. R., 100 feet by 90 feet; at Milwaukee, C., M. & St. P. Ry., 100 feet by 97 feet; at Silvis, C., R. I. & P. Ry., 154 feet 6 inches by 104 feet 11 inches; at Elizabethport, C. R. R. of N. J., 118 feet by 101 feet; at Collinwood, L. S. & M. S. Ry., 132 feet by 85 feet; at South Louisville, L. & N. R. R., 141 feet 4 inches by 110 feet; at Reading, P. & R. R. R., 175 feet by 112 feet; at McKees Rocks, P. & L. E. R. R., 100 feet by 75 feet.

While the rule is not followed without exception, the boiler room is usually of the same dimensions as the engine room, the interior of the building being divided equally by a longitudinal wall. At Topeka, the building is divided by a transverse wall and the building is long and narrow as compared with other power houses. This is probably due to the rather limited space which could be allotted to the power house.

The longitudinal division is considered more satisfactory as providing for a shorter distance between boilers and engines and thus requiring shorter piping connections.

The modern engine room is universally served by an overhead traveling crane serving the entire floor and operated by hand from below. The crane is usually of about 7½ or 10 tons capacity, though in rare cases this has been increased to 20 tons.

Feed water pumps, heaters, fire pumps, and other auxiliaries are frequently provided for in the basement beneath the engine room, thus removing them from plain sight and at the same time locating them where they will be free from the dust and dirt of the boiler room.

COAL AND ASH HANDLING EQUIPMENT.

Coal and ash handling equipment vary in degrees of development in the railway shop power plant. At many prominent shops, however, very complete automatic systems of handling coal and ash are in service and no manual handling of coal is necessary from the time it leaves the car on which it is delivered until reaching the grates.

The method by which fuel is handled from the car to the grates is a very essential factor in the operation of the power plant. Owing to the comparatively cheap cost of fuel to a railroad company and the small expense for delivery, the price of fuel delivered to the outside of the power house is not great. This, however, does not represent the entire cost of the fuel. The final cost includes all the expense of handling coal between the delivering cars and the grates, in addition to the expense of removing and disposing of a proportionate amount of ashes. Therefore the more economical the method of handling coal after it leaves the car the cheaper the cost of fuel. As the amount of coal used is from ten to twenty times the weight of the ashes to be removed, it is more economical to provide for handling the coal cheaply. Nevertheless the amount of ash to be disposed of is an item sufficiently large to justify economical methods of handling it as well. Those plants having complete automatic systems for handling coal, usually handle ash with the same apparatus, using separate hoppers for its temporary storage.

At those power plants containing the most modern equipment, mechanical stokers are generally employed to reduce the fire room force, and it is desirable to chute coal down from storage bins overhead to the stoker hoppers. Even with hand firing, it is more desirable to chute the coal in a similar manner, rather than to have it shoveled into cars or wheel barrows and dumped in front of the boilers or shoveled from the cars direct to the grate.

The chutes or spouts by which coal passes down from the storage hoppers overhead should be designed to avoid clogging Coal, like gravel, has a tendency to form arches between the walls of the chute through which it is passing and when this occurs it is necessary to clear the chute by poking the coal from time to time. Square chutes are less liable to become clogged than round ones, and the larger the pipe, the less the liability to clog.

The most common system for the delivery of coal to overhead storage hoppers is the bucket conveyor system. It is possible to provide for horizontal and vertical runs for the conveyor system and this system lends itself most readily to railroad shop power plant conditions.

A feature of this system which is likely to produce a failure is the high fibre stress to which the pins are subjected. Continued care is necessary to guard against the pins being cut to a dangerous degree within a comparatively short time. For this reason automatic clutches have been recommended to hold the conveyors in case of an accident or failure.

By the conveyor system, coal is dumped from cars standing on a track adjacent to the power house, into a receiving pit. From this it is led by a gravity feed conveyor to a crusher. Coal from the crusher either falls directly into the buckets of the conveyor system, or falls into a hopper and then to the buckets. An endless chain bucket conveyor then hoists the coal to the upper portion of the building and dumps it into storage bins located above the boilers, from which it is led by chutes to the stoker hoppers.

A few concrete examples will best serve to illustrate the methods of handling coal and ash in the railway shop power houses of to-day.

COAL AND ASH HANDLING EQUIPMENT AT DANVILLE, C. & E. I. RY.

At the Danville shops of the Chicago & Eastern Illinois Railroad, the floor of the boiler room is on the

ground level and along one wall of this room the coal bunkers are arranged. As originally constructed the bunkers were of such height that coal could be shoveled by hand from cars standing on the track alongside. Provision has been made for the arrangement of tracks over the bunkers in order to dump coal directly from hopper cars.

The bottoms of the bunkers are hopper shaped and the delivery of coal from them is controlled by gates operated by a shaft and hand wheel, the latter being arranged in the boiler room within reach of the fireman. Coal from the bunkers is delivered into hand cars which may be drawn forward to positions accessible to the firing doors. From the cars coal is fed directly to the grates by hand.

Ash is handled by a telpher system. Directly in front of the ash doors is a trench of such width as to accommodate a specially designed bucket. When this bucket is lowered into the trench ashes are drawn from the ash pits to the bucket. When filled the bucket is drawn up by a motor and conveyed along an overhead track through a door in the wall of the boiler room and dumped directly into a car placed on a switch track near the boiler room, to receive ashes.

COAL AND ASH HANDLING EQUIPMENT AT COLLINWOOD, L. S. & M. S. RY.

At Collinwood, on the Lake Shore & Michigan Southern Railway, the automatic system of handling coal and ash is very complete and the labor necessary in the boiler room is reduced to a minimum. The coal storage pockets and ash bins are of steel and concrete, built permanently into the upper portion of the boiler room. The coal pockets are supported upon 21 inch built up plate girders, 18 feet 6 inches long, which extend from steel posts set in the wall of the boiler room to similar steel posts located between the boiler settings. Upon these girders rest special triangular shaped plates arranged to support the sloping portions of the base of the bin, these portions being built up of 9 inch 18 lb. I beams laid longitudinally and filled in between with concrete. The ends of the trough shaped bottom of the bunkers are so constructed as to slope from the edge of the stoker feed holes to the end walls, preventing the accumulation of coal at the ends. These end portions are of similar construction as that described for the sloping base. The side and end walls of the pockets are built up of 8 inch 18 lb. I beams with solid concrete filling between them.

The ash bin is similar in construction to that of the coal pockets, with the exception of being smaller and of different shape. The entire base slopes in one direction, at an angle of 45°, toward the outer wall of the boiler room. The lower end of the base terminates in a chute extending through the wall and having a 24 inch clearance. The outer end of the chute terminates in a lip hinged to the wall and so counter-weighted as to swing up and down easily. When raised up, the lip acts as a door to close the chute, and when down, as a trough for delivery to a car placed on an adjacent track.

Coal is delivered to the power house by dumping direct from the car into a pit located outside of one corner of the boiler room. This pit is directly underneath the side track which extends along the side of the boiler room and from this pit coal enters the conveyor system. The pit contains a receiving hopper of ¼ inch steel plate, which receives coal as it is dumped from the car and directs it into a short auxiliary open feed conveyor, carrying it to the crusher and main conveyor within the boiler room basement. The open feed conveyor discharges the coal into a hopper feeding into the coal crusher and the crusher breaks it up, if necessary, to the size required for the stokers. After leaving the crusher the coal drops into a hopper below, from which it is fed into the main bucket conveyor system for delivery to the coal pockets above.

The open feed conveyor feeds into the crusher's hopper in regular quantities, avoiding clogging or overloading the crusher. The crusher is of a very heavy pattern, 24 inches by 24 inches in size, with a solid tooth roll. Both the crusher and the apron feed conveyor are run by a 22 horse-power electric motor. The main conveyor is of the pivoted bucket type, consisting of malleable iron buckets, 18 inches by 24 inches in size, pivoted to two strands of 24 inch pitch chain, which is fitted with self oiling flanged rollers for running on the conveyor track. The buckets have overlapping ends, thus forming a continuous trough, which does not open anywhere in transit except when on vertical section of conveyor track or when passing the dumping carriage, and thus does not require a feeder hopper. The dumper carriage is a tripping mechanism arranged below the conveyor track over the coal pockets, which will dump the pockets as they pass. The dumper carriage may be placed at any location over the pockets for dumping and filling the section desired, its position being adjustable from the boiler room floor.

This main conveyor provides for the removal of ashes from the furnaces. Ash pits of bowl shape are located in the boiler foundations below the stokers from which the ashes may be scraped into the conveyor passing in front. By properly adjusting the dumper carriage over the ash bin above, the conveyor buckets dump their contents into the bin, where the ash is ready to be loaded into cars outside.

The main bucket conveyor is operated by a 7½ horse-power electric motor, through a special set of equalizing gears transmitting an even motion. The conveyor travels on a track of 16 lb. T rails.

Ash is dumped from the bins to cars standing on the same track on which loaded coal cars are received for delivery to the power house. Thus the same cars may be used for the removal of ashes and no additional switching is required.

COAL AND ASH HANDLING EQUIPMENT AT MCKEES ROCKS, P. & L. E. R. R.

The system by which coal and ash are handled at McKees Rocks, P. & L. E. R. R., is to a certain extent similar to that described for Collinwood. Coal is delivered to the power house in cars over a spur track leading past one corner of the boiler room. This track passes over a receiving hopper, into which the coal may be dumped directly from hopper cars. The coal thence passes through a proper grating and is hoisted by an endless chain bucket conveyor to the top of the building. Here it is dumped upon a horizontal conveyor, which deposits it at the points desired in the coal storage bins located in the upper part of the boiler room and arranged to feed into the stoker hoppers directly by chutes. The hoisting mechanism is operated by a 10 horse power electric motor located in the basement and the horizontal conveyor is operated by a 7½ horse power motor. The actual power required by the two conveyors when running is about 7½ and 4 horse power respectively. The capacity of this hoisting and conveying equipment is 40 tons per hour, the total storage capacity of the coal bunkers being 200 tons.

Ashes are handled by the same hoisting conveyors as those used for coal delivery, an ash receiving and storage pocket having been arranged upon an elevated structure above the coal receiving track. When a car load of coal has been dumped into the receiving pocket below, the car may be used for removing the ashes without further switching Ashes are dumped directly from the bin to the car.

Ashes are handled from the ash pits beneath the boilers by special wheel barrows and then dumped into the hoisting conveyor, which may be arranged to deliver at the top into the ash hopper side.

The ash bin is of concrete upon steel frame work, with the lowest point of the hopper 16 feet above rail level. The coal hoppers, six in number, are of similar construction, with their outlets 12 feet above the boiler room floor. The coal outlets are controlled by special gate valves operated from the floor by chains passing over the wheels. Coal is distributed to the various pockets by the horizontal conveyor, which may be arranged to dump at any point. A protection for the top of the hoisting conveyor is provided for by a small enclosure above the roof.

COAL AND ASH HANDLING EQUIPMENT AT READING, P. & R. R. R.

At the Reading power house of the Philadelphia & Reading Railroad, coal is stored in a series of elevated hopper bins, of 300 tons capacity, located above the fire room, from which it is delivered direct to the stokers by chutes. The bins are of built up steel construction and are supported partially from the side wall and partially from the roof trusses, which are extra heavy in order to provide additional strength for this purpose. By this construction the fire room is free from obstructions. Coal is delivered into the bins by a conveyor system, having a capacity of 100 tons per hour, which carries it from a receiving pit under a delivery track at one side of the building and distributes it, in connection with a scraper conveyor above the pockets, into any desired bin. The coal used is buckwheat grade, containing about 20 per cent of ash.

The ash conveyor system is entirely separate from the system handling coal. It consists of a scraper line leading through an ash tunnel under the ash dumping portions of the grate and it delivers underground into a separate ash storage building outside of the boiler room. In this ash building another elevator conveyor raises the ashes to elevated bins, from which the ashes are dumped into cars for removal. The ash storage building includes a number of interesting features. The bin floor slopes at an angle of about 45° toward the dumping side and it is lined with 1 inch glass plate. This produces an absolutely non-corrosive surface, upon which the ashes slide with great freedom.

COAL AND ASH HANDLING EQUIPMENT AT SILVIS, C., R. I. & P. RY.

The arrangement of the coal and ash conveying machinery at the Silvis power house of the Chicago, Rock Island & Pacific Railway, is simple and direct. Coal is delivered directly from hopper cars to a hopper just above the steam driven coal crusher and after passing through the crusher is conveyed to overhead storage hoppers by an endless chain bucket conveyor system, which has a capacity of 50 tons of coal per hour. Each boiler has a storage bin of 32 tons capacity.

The conveyor also carries ashes from the ash pits to a hopper located in a wing and over the coal hopper, so that the hopper car when it has been emptied of its load of coal may be filled with ashes. The steam engine which drives the conveyor is situated in the upper portion of the building above the level of the coal pockets. Steam is used in preference to electricity as a motive power for the crusher and conveyor, as it was believed by the designers of this plant that occasions may arise when it is desired to handle coal or ashes when the generators are not running and also because in case of stalling the motor would be liable to injury while the engine would simply slow down and stop.

COAL AND ASH HANDLING EQUIPMENT AT SOUTH LOUISVILLE, L. & N. R. R.

In principle, the coal and ash conveyor system installed in the power house of the Louisville & Nashville Railroad at South Louisville is similar to those already described. Coal is delivered from a track at one side of the building and ash is dumped by gravity from elevated bins into cars on the same track. Coal and ash are elevated by an endless chain bucket conveyor system.

Coal is fed to the stokers from overhead storage pockets, of steel and concrete construction, which have a capacity of 1,000 tons, sufficient to operate the plant

for at least three weeks. From the cars coal is shoveled into curved chutes, which conduct it to a crusher and feeding device, after which it passes to the conveyor. The coal crusher is operated by a 20 horse power motor. The conveyor travels at the rate of 40 feet per minute, delivering 40 tons of coal per hour.

BOILERS.

There are many different makes of boilers installed in railway shop power houses. As a type, however, the water tube boiler is used with but few exceptions in representative power houses. The horizontal water tube boiler is used so extensively that it may be said almost to cover the field. At Reading on the Philadelphia & Reading Railroad, at Sayre on the Lehigh Valley Railroad, and at Grand Rapids on the Pere Marquette Railroad, vertical water tube boilers are in service, and at Topeka on the Atchison, Topeka & Santa Fe Railway, fire tube boilers of the locomotive type have been installed.

The increasing use of water tube boilers arises largely from the fact that this type permits steam to be raised very rapidly in response to sudden demands, owing to the smaller quantity of water contained in proportion to the heating surface and due to the better circulation. While no boiler is absolutely safe from explosions, such accidents seldom occur in water tube boilers, though the tubes burst occasionally. The water tube boiler requires a firing aisle of sufficient width to allow the removal and insertion of tubes without obstruction.

BOILER PRESSURE.

A review of a large number of representative railway power plants would lead to the conclusion that 150 lbs. pressure is considered the most satisfactory for this class of work. Frequently one boiler is installed having a capacity of 250 or 300 lbs. pressure, for use in testing locomotives and provided with reducing valves for use with other boilers. They are usually arranged in batteries of two boilers in each with intervening spaces for access. As originally constructed, space is usually left for the future installation of at least one additional battery of boilers. The boilers are arranged in a single row. The horse power of each boiler varies at different plants from 200 to 500.

Due to the comparatively low cost of fuel to the railroad companies incentives to fuel economy have not been so great as in commercial power stations. At the same time the single central power house has illustrated that the boiler room offers a great opportunity to reduce operating expenses. The result is that the boiler room of the new central power house compares favorably in equipment with the boiler room of manufacturing concerns.

STOKERS.

While there are still many stationary boiler plants which are fired by hand, mechanical stokers are now generally used in the larger central power stations. This system not only reduces labor in the boiler room, but prevents cold air from impinging on the hot tubes and plates of the boiler and causing leaks.

There are a number of mechanical stokers on the market, which are divided naturally into two classes, the underfeed and the overfeed. The overfeed, almost exclusively is used in railway shop power stations, and generally with natural draft. The underfeed cannot be used without forced draft.

The type of mechanical stoker which seems to have received the greatest favor in railway shop power stations is the traveling chain grate stoker. This consists of a wide band or chain, made up of short link like sections of grate bars pivoted after the fashion of a sprocket chain. The chain is endless and travels around two drums in the firebox, being so driven that the upper side moves backward from the boiler front toward the arch. Coal is fed evenly on the moving chain as it recedes by a feeding hopper in front of the boiler, the hopper being supplied directly by coal chutes leading from storage pockets above. The fuel burns as it travels with the grate, the speed of travel being so adjusted that when the rear drum is passed, the coal is entirely consumed, leaving ashes only to be dumped off at the end. With this system, it is therefore not necessary to open the door to clear the grates or "bar" the fire.

The stokers are driven by small vertical steam engines geared to drive the drums very slowly through ratchet mechanisms. It is appropriate to say that steam engines are usually considered preferable to electric motors for this service, inasmuch as they may be run when getting up steam or at any time that steam is on, and are not dependent on the dynamos being in operation. The entire chain grate mechanisms are mounted in frames with wheels running on tracks embedded in the boiler room floor, in order that the stokers may be easily withdrawn from the boiler settings for inspection or repairs.

Where a planing mill is operated in connection with the shop plant, it is customary to fire some of the boilers by hand and so dispose of shavings, sawdust and other wooden refuse. For instance, at Angus, of the seven boilers installed, three are equipped with mechanical stokers and four are arranged for hand firing and to receive shavings, etc., from an extensive shavings exhaust system from the planing mill and cabinet shop. At Collinwood one boiler is fitted with stationary grates instead of a stoker in order to burn shavings and refuse. At South Louisville two of the boilers having chain grates are equipped to burn shavings and two boilers are hand fired to use the same kind of fuel.

CHIMNEYS.

Tall chimneys for draft production continue to be built in connection with railroad shop power stations. While a few power houses are equipped with mechanical draft, notably Silvis, C., R. I & P. Ry.; Jackson, M. C. Ry., and Angus, C. P. Ry., the larger number depend on draft obtained by tall chimneys. Except for some of the short stacks used in connection with mechanical draft equipment, steel chimneys have not been installed. The chimneys are built of

common brick or radial brick, usually the latter. A common form is a chimney with a square base built of common brick, with the upper portion circular in form and built of radial brick. The brick in the circular portion of the chimney is often of specially baked clay. While not confined to these limits the heights of chimneys at a number of prominent shops vary from 120 feet to about 185 feet.

The chimney of the power plant of the Louisville & Nashville Railroad, at South Louisville, is of careful design and worthy of mention. It is 182 feet high, with a flue 9 feet 6 inches in diameter. For a height of 60 feet the wall is 40 inches thick, and the cross-section of the chimney is square. Above this height the cross-section is circular. The wall is built in sections 16 feet 5 inches in length. The thickness of the wall of each succeeding section is made smaller, until for the top section it is only 8⅝ inches thick. The chimney is topped with a cast-iron cap. The lining of the chimney is of fire brick carried on bracket projections, making it possible to renew any section of the lining without dsturbing the rest and allowing for expansion in various parts. The chimney is built of perforated radial bricks, made from specially selected clay and burned in a high temperature to render them dense and impervious to moisture. Opposite to the opening for the flue is a balance opening of the same shape and size in order that the settlement on the two sides will be equal and therefore prevent cracking or a tendency of the chimney to cant to one side. The balance opening is closed on the outside by a dummy wall.

MECHANICAL DRAFT.

Comparatively few power stations operated in connection with railway shop plants are equipped with apparatus for providing mechanical draft. With natural draft it is rarely possible to burn more than 40 lbs. of coal per square foot of grate area per hour, while with forced or induced draft the amount of coal burned may be as high as desired. Among the advantages to be obtained with mechanical draft may be mentioned reduced size of chimney, smaller boiler plant, control of draft in a manner that may be regulated to suit requirements, use of low-grade fuel. The disadvantages of the mechanical draft system lie in the addition of the mechanical equipment which must be maintained, and in the expense of operation of the apparatus.

As the combustion of fuel depends upon the intensity of draft available, the draft is an important factor, for the operation of the power plant is dependent upon the combustion of fuel. The intensity of the draft required depends upon the quality of fuel used and upon the quantity to be burned per square foot of grate area per hour. Therefore insufficient draft is a cause of serious trouble. By means of a strong draft it is possible to force boilers in case of overload, and sufficiently strong draft is equivalent to a certain amount of additional boiler heating surfac. With a strong draft the use of cheap, low-grade fuel is successful.

Mechanical draft as applied to railway shop power station service is usually induced draft and is produced by fans. The fans deliver smoke and gases through short steel stacks varying in height from about 48 feet to 70 feet, and the mechanical apparatus is depended upon entirely for the draft produced. The mechanical draft is under complete control at all times and may be regulated to suit the load carried. The apparatus is usually installed in duplicate, and while each fan is capable of disposing of all smoke and gases from the entire boiler installation, one fan is held in reserve in order to shut down one engine and fan in case of necessary repairs.

DRAFT SYSTEM AT READING, P. & R. R. R.

At the Reading shop power house of the Philadelphia & Reading Railroad, natural draft is provided by a brick stack 125 feet high with an inside diameter of 10 feet. The chimney draft is supplemented by a fan on the forced draft system, the requirements calling for both an air pressure below the grate and an exhaust above. The undergrate forced draft is furnished by a 10-foot blower fan delivering through an underground flue in front of the boilers. Dampers are provided at each boiler to regulate the air pressure as well as to regulate the effect of the natural draft.

The reason for providing both natural and forced draft is that both were required with the stoker as installed in order to obtain the desired working efficiency of 10.5 lbs. of water evaporated per pound of combustible.

DRAFT SYSTEM AT SILVIS, C., R. I. & P. RY.

The more common system, where mechanical apparatus is installed, is induced draft produced by fans. The induced draft apparatus at the Silvis plant of the Chicago, Rock Island & Pacific Railway consists of two exhaust fans 12 feet in diameter and 6 feet wide driven by 12 by 12-inch horizontal single cylinder engines. The speed of the engines is regulated by regulating valves. Either of these fans is of sufficient capacity to handle all the gases from the complete boiler equipment, and dampers are provided to cut off whichever fan is not in use. The stack is of steel, 60 feet high and 7 feet 8 inches inside diameter.

DRAFT SYSTEM AT ANGUS, C. P. RY.

Induced draft in the boiler plant of the Angus shops of the Canadian Pacific Railway is produced by two 10-foot fans, operated in connection with a steel stack 70 feet high and 8 feet in diameter. Each fan is connected with all of the boilers and runs at about 200 revolutions per minute.

DRAFT SYSTEM AT JACKSON, M. C. RY.

The boiler plant of the Michigan Central shops at Jackson, Mich., is operated with induced draft. The apparatus consists of two 7-foot blast fans operated in connection with a steel stack 48 feet high and 60 inches diameter. Each fan is direct connected to a vertical steam engine having a cylinder 8 inches in diameter and 6-inch stroke. The fans are arranged one above the other for economy of space, the upper fan and its engine being supported upon a steel platform of I beams, 9 feet 4 inches above the floor. The

blast wheel of each fan is mounted directly upon an extension of the engine's shaft. The blast wheel is 84 inches in diameter, with a face 42 inches wide. Each fan has a delivery outlet 48½ by 42 inches. Either fan is capable of handling the gases from all of the boilers.

ECONOMIZERS.

The boiler plants operated in connection with mechanical draft appliances have usually been equipped with economizers. However, comparatively few economizers have been installed in railway shop power houses, and the extent to which they have been omitted would lead to the conclusion that they have been so far looked upon as refinements somewhat beyond immediate needs, in view of the comparatively low cost of fuel.

Economizers introduce considerable friction in the flue system in addition to the loss of draft caused by the heat abstracted from the waste gases, the drop varying from 0.20 to 1.00 inch of water, according to the length of the economizer, its area and the number of elbows it causes in the gas passage. The straight passage economizers cause less friction than those with staggered tubes, but the staggered tubes should be more efficient as heat absorbers.

PIPING.

With the development of the central power plant, the piping represents a marked improvement. This is noticeable not only in the material provided and in the improved construction of joints, but also in the arrangement of easy bends of large radius to provide for expansion and to eliminate the obstruction due to elbows and short curves, as well as in the convenient disposition of the pipes. By dividing power houses longitudinally with a single wall separating the boiler and engine rooms, and by locating boilers and engines with a comparatively short distance between them, the length of piping is reduced.

The main steam header is supported back of the boilers on specially designed suspensions or supports. The header is usually 10 or 12 inches in diameter and of the same diameter throughout its length. Steam is led from each boiler to the header through a pipe having an easy bend of large radius. Connections to the engines are led from the header to the engine throttles in easy curves. Separators are placed in the steam pipes leading to the engines either just above the headers or above the engine throttles. The pipes are connected to the headers on top in order that no water of condensation will be entrained in the pipes and provision is made for draining the header.

Steam pipes are either carried through the partition wall and direct to the engine throttles or are carried through the basement. There is a tendency in power house practice to dispense with all piping above the floor, in which case the pipes are carried in the basement beneath the engine room floor. This arrangement not only removes an unsightly obstruction from the engine room but places the pipes in position where they are easy of access.

ENGINE EQUIPMENT.

As the development of the central power plant in railroad shop practice is a result of a demand for the generation of power at one point, with electrical distribution to the various points of consumption, it naturally follows that the engine equipment of such stations is selected for driving electrical generating machines. For this work, horizontal, cross-compound, non-condensing engines are usually employed, though tandem-compound and vertical engines are installed in some railway power plants, and the condensing engines in the power house of the C. M. & St. P. at Milwaukee are exceptional.

It has not been considered that the advantages in the line of economy gained by triple or quadruple expansion engines pay for the added complications introduced. Such engines show up to their best advantage only under practically constant load, and in an electrical generating plant the load is very variable. The engines are usually non-condensing, as the exhaust steam is used for heating the shop buildings, and the cost of fuel is such that condensers seem to be a refinement beyond present-day requirements.

Each engine is direct connected to an electrical generator, and in the central power plant a belt-driven dynamo is a rarity. The speed of the dynamo is then dependent upon the speed of the engine, and as the larger engines operate at a comparatively low speed, the smaller unit is more economical and satisfactory. Of the information at hand the engine of largest capacity installed in a railway shop power plant is one of 900 horsepower at the West Albany plant of the New York Central Lines.

It is usual to install two or more main units for the maintenance of power for the operation of the plant under the usual conditions of service, while a smaller unit is installed for supplying power for lights at night and for light power at such times as it may be unnecessary to operate the larger machines.

STEAM TURBINES.

Thus far there are very few examples of the installation of steam turbines, or rather, turbo-generators in railway shops. In 1903 three units of 300-h. p. each direct connected to two generators were adopted in the Aguas Calientes shops of the Mexican Central. This year the new El Paso shops of the El Paso & Southwestern Ry. have been equipped with three turbo-generator sets, each consisting of a 150-h. p. De Laval steam turbine, direct connected to two 50-k. w. 250-volt generators. The new shops of the Big Four at Indianapolis are to be equipped with Curtis turbo-generators, and the new shops of the D., L. & W. R. R., now under construction at Scranton, Pa., will be provided with turbo-generators.

The steam turbine is a splendid power generator, and under conditions favoring its use probably excels steam reciprocating engines in several respects. However, it is well recognized that under less than its full load its economy falls off more rapidly than the reciprocating engine. Also it is imperative that it should

be operated condensing, and in many railway shops it is preferable to use the exhaust steam for heating the buildings. Again, the cost of providing water for condensing purposes often renders it more desirable to operate non-condensing. Tribe says that 20-foot lift and 500 feet of pipe should be regarded as the limit distance through which condensing water should be drawn by the vacuum of the condenser. This explains the very general use of compound non-condensing engines in most railway shops.

GAS ENGINES.

There is no information at hand of railway shops where the gas engine has been introduced to supply the power. The increasing use in other fields of the gas engine in connection with gas producer plants of either the suction or pressure type, however, causes one to be safe in thinking that the great economy of such plants will cause them to be considered for railway shop use before long.

ELECTRICAL CURRENT.

The various installations which have been placed in the most prominent railway shop plants put in operation within comparatively recent years are not sufficiently alike to lead to a conclusion as to the electrical system considered most satisfactory under conditions peculiar to railway shop work. The arrangement looked upon with greatest favor is the installation of alternating current circuits for the operation of all constant speed motors, for instance, those driving wood-working machines and groups of metal-working machines, as well as for lighting, and direct current circuits for driving individual variable speed motors attached to large metal-working machines and motors for traveling cranes and transfer tables.

There is an opinion more or less widely circulated that individual driving of metal-working machines has been carried to too great an extent, and that better results would be obtained with fewer machines direct connected.

In a number of instances railway shop power stations provide power for lights not only throughout the immediate shop plant, but also to passenger stations, freight yards, etc The distances over which this power must be transmitted are frequently great, and alternating current is eminently the most satisfactory, as this current is particularly adapted for long-distance transmission, due to its high voltage.

Owing to the different methods of distribution in service in various shops, it is instructive to note the individual methods of distributing electrical power at several prominent shops.

DISTRIBUTION OF ELECTRICAL POWER AT COLLINWOOD, L. S. & M. S. RY.

The general electrical distribution of the Collinwood shops of the L. S. & M. S. Ry. is a two-wire system operating at 240 volts, and in addition to this is a four-wire multiple voltage system for use in obtaining variable speeds at the motors of the motor driven mechanical tools in the locomotive shop. The distances from the power house to the various points of power consumption are not great. The point of consumption located at the greatest distance is the roundhouse, where power is used for operating the turntable and which is lighted electrically. The roundhouse is about three thousand feet from the power house.

The distribution of power at the McKees Rocks shops of the P. & L. E. R. R. is by the same system as that at Collinwood.

DISTRIBUTION OF ELECTRICAL POWER AT DANVILLE, C. & E. I. RY.

At Danville, on the C. & E. I., the distribution of electrical power is by a 250-volt direct current system using the two-wire system of distribution for motors and the three-wire system for lighting. The average distance of transmission is not over 800 feet.

DISTRIBUTION OF ELECTRICAL POWER AT SILVIS C., R. I. & P. RY.

Direct current transmission is used at the Silvis shops of the C., R. I. & P. Ry. For power delivered to cranes, heating fans and constant speed machine motors, distribution is by the two-wire system at 230 volts. For variable speed machine motors and for lighting, distribution is by three-wire 230-115 volt lines.

DISTRIBUTION OF ELECTRICAL POWER AT ANGUS, C. P. RY.

At the Angus shops of the Canadian Pacific Railway both alternating and direct current systems are used. The direct current system is used only for the transfer table, traveling cranes and for a few individually driven machine tools requiring variable speed motors. The alternating current is 3-phase, 60-cycle and 600-550 volts. The direct current is at 275-250 volts.

DISTRIBUTION OF ELECTRICAL POWER AT JACKSON, M. C. RY.

During the year 1903 a modern power plant was completed at the Jackson, Mich., shops of the Michigan Central Railway. This provided for the electrical distribution of power from a single point and replaced four separate isolated power plants of boilers and engines which were scattered around adjoining various shop buildings. This plant also provided power for lights at several points removed some distance from the shop.

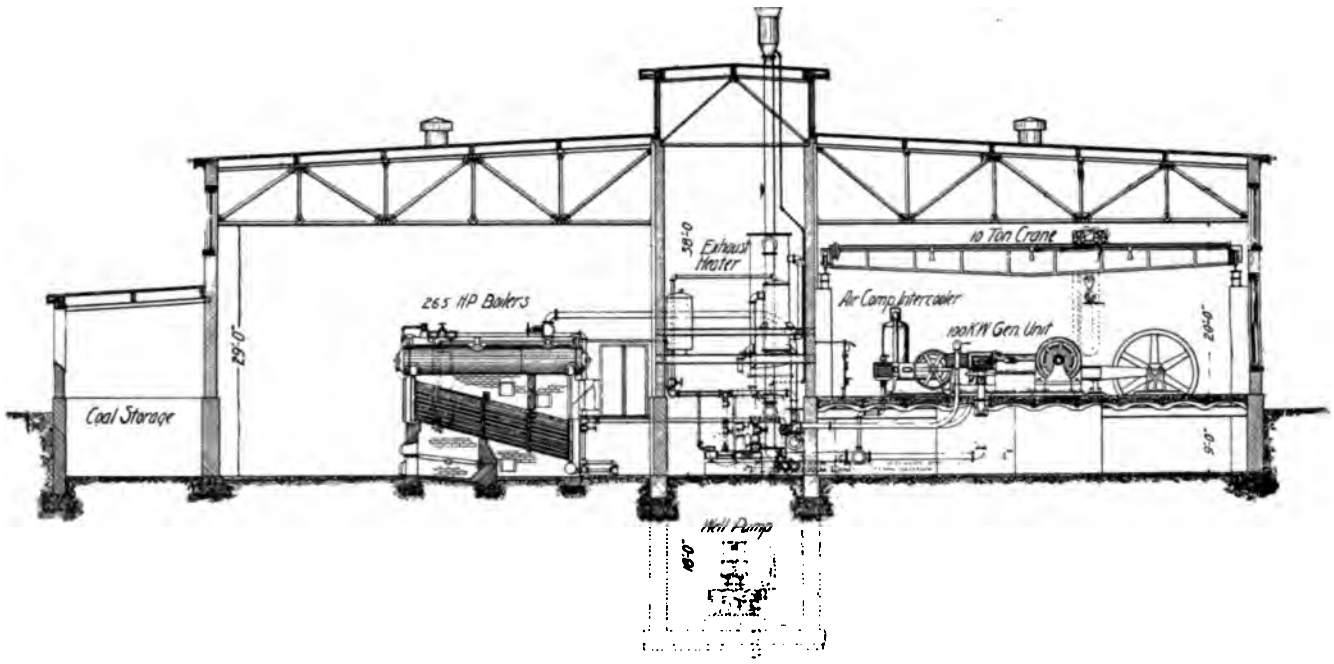
The alternating current system alone has been installed and provides power for all machine tools, cranes and lights. This is the alternating current, 3-phase, 60-cycle system operating at 480 volts.

DISTRIBUTION OF ELECTRICAL POWER AT WEST ALBANY, N. Y. C. LINES.

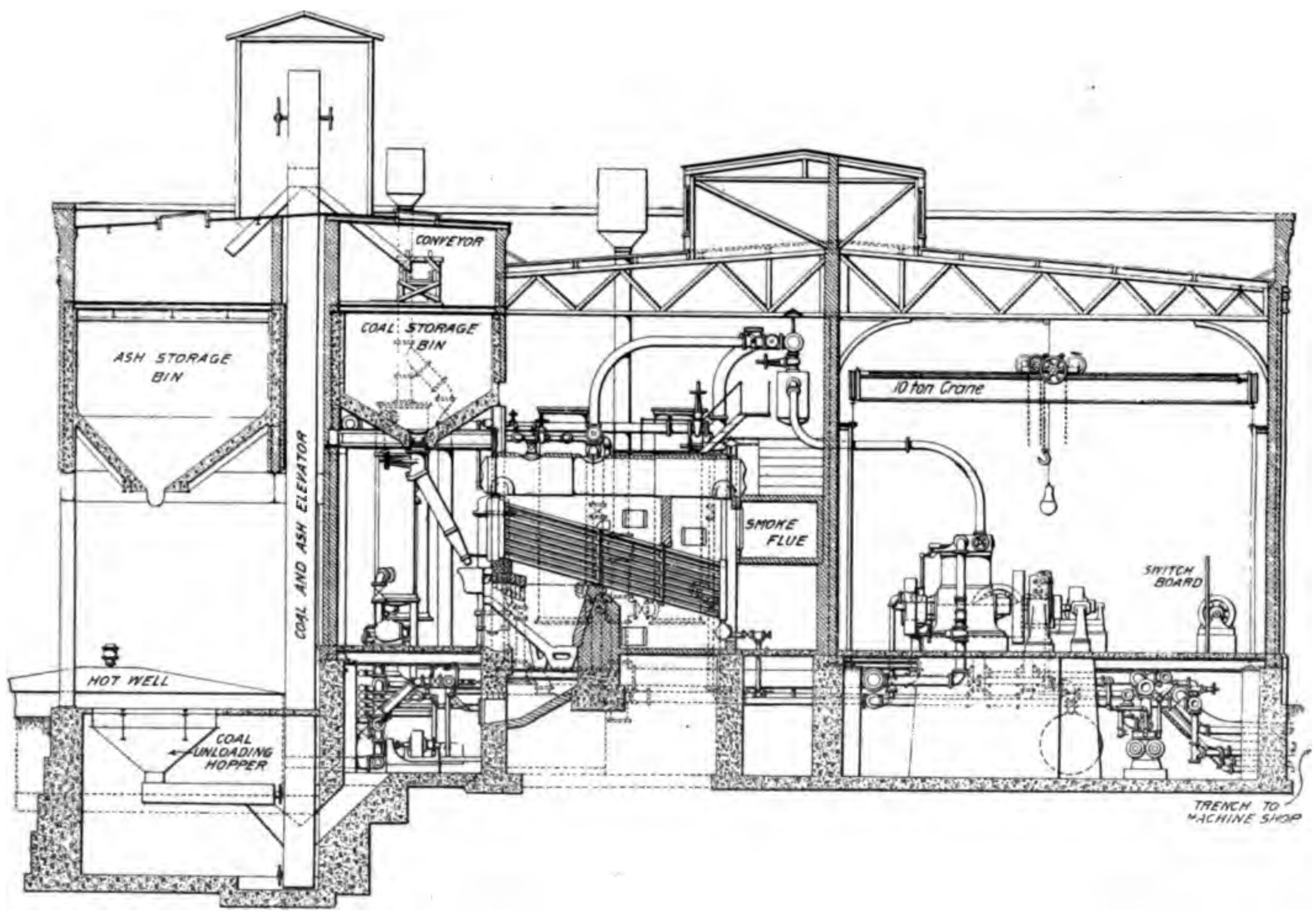
At the West Albany power plant of the New York Central Lines alternating current generators supply 3-phase current at 60-cycle per second at 480 volts for light and power. As the main power circuits are all alternating, direct current is supplied for the cranes by a motor generator set. The set consists of a 60-cycle, 3-phase alternating motor of 900 revolutions per minute and 480 volts, and a multipolar 250-volt direct current generator.

Data of Representative Power Houses

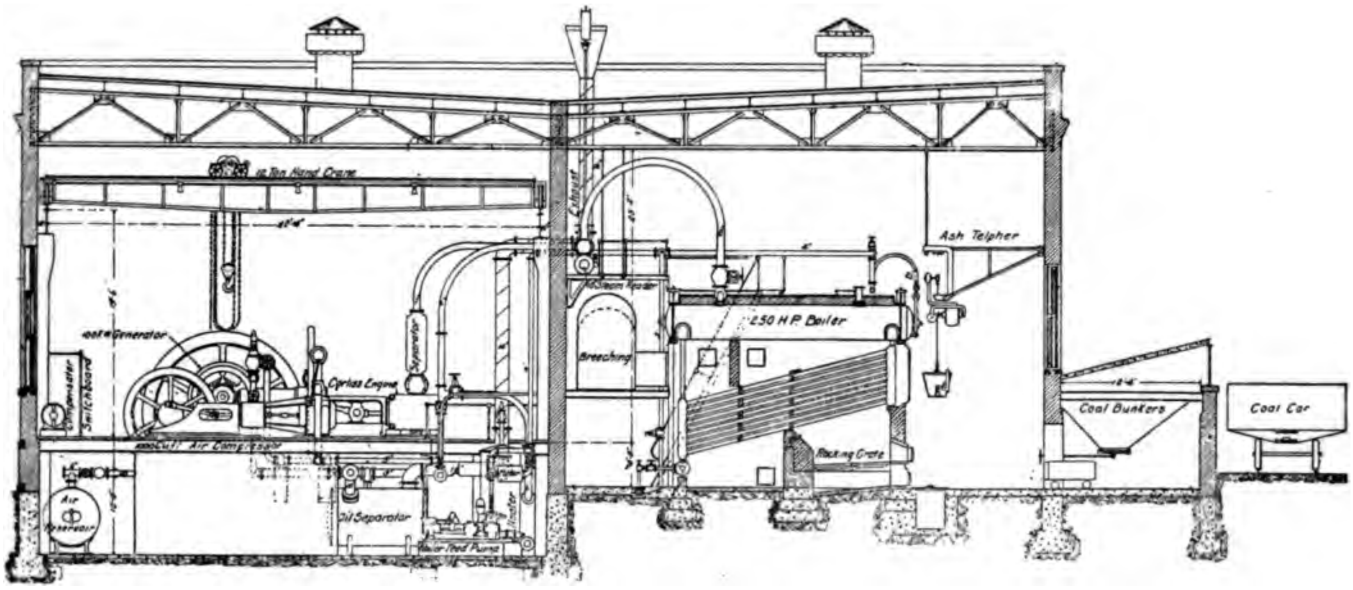
Road	Location	Size Bldg.	No. of Boilers	H. P. each Boiler	Total Boiler H. P.	Steam Press.	Type Boilers	Air Comp. cu. ft.	Type of Engine	No. of Engines	H. P. Each Engine	Total Engine H. P.	K-W. Each Gen.	Total K. W.	Current	Volts
A. T. & S. F.	Topeka	176x56-9	7	200	1400	150 250	Fire Tube Locomotive	3500	Horiz. Cross Comp.	4	325 120	1095	200 75	675	D C	230
B. R. & P.	DuBois	92-9x63	5	200	1000	150	Horizontal Water Tube	1300	Vert. Cross Comp.	4	200 100	600	125 75 65	390	D C A C	220 2200
C. P.	Angus	216x103	12	416	4868	150	Horizontal Water Tube	6000	Horiz. Cross Comp. and Simple	6	750 375 300	3675	500 250 200	2450	A C D C	600 550 275 250
C. & E. I.	Danville	100x90	7	264 300	1956	125	Horizontal Water Tube	2000	Simple	3	750 300 150	1200	500 200 100	800	D C	250
C. M. & St. P.	Milwaukee	100x97	4	300	1200	150	Horizontal Water Tube	1200	Horiz. Cross Comp.	3	330 160	820	200 100	500	D C	250
C. R. I. & P.	Silvis	154-2x104-7	6	300	1800	150	Horizontal Water Tube	3000	Cross Comp.	2	667 333	1000	500 250	750	D C	250
L. S. & M. S.	Collinwood	135-6x88-6	6	300	1800	150	Horizontal Water Tube	3000	Horiz., Vert., Cross Comp. and Simple	4	650 480 150	1930	400 300 75	1175	D C	250
L. & N.	S. Louisville	141-4x110	8	305	2440	180	Water Tube Vertical (Curved)	3400	Horiz. Cross Comp.	3	550	1650	350	1050	D C	240 to 250
M. C.	Jackson	93-7x98-6	4	264	1056	150	Horizontal Water Tube	1750	Tandem Compound	4	100 250	850	200 60	660	A C	480
N. Y. C.	W. Albany	113-4x92-8	4	500	2000	200	Horizontal Water Tube	....	Horiz. Cross Comp.	2	900	800	600	1200	A C	480
P. & R.	Reading	175x112	8	250	2000	150	Vertical Water Tube	1500	Tan. Comp. and C. C.	4	300 600	2100	200 400	1400	A C D C	480 125
P. & L. E.	McKees Rocks	102x81	6	264	1584	150	Horizontal Water Tube	2000	Vert. Cross Comp.	5	250 410	1410	150 250	850	D C	240
St. L. I. M. & S.	Baring Cross	131x78-9	5	250 550	1550	150	Horizontal Water Tube	3000	Tand. Comp. Vert. Comp. Simple	4	75 160 175 290	700	50 100	450	D C	220
C. R. R. of N. J.	Elizabethport	118x101	3	500	1500	120	Horizontal Water Tube	2800	Simple	5	175	875	100	300	D C	240
Big 4	Indianapolis	116-10x129-8	6	400	2400	5-165 1-225	Water Tube	2000	Turbines	3	670	2010	500	1500	A C	440



CROSS SECTION OF POWER HOUSE AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



CROSS SECTION OF POWER HOUSE AT McKEES ROCKS, PA., P. & L. E. R. R.



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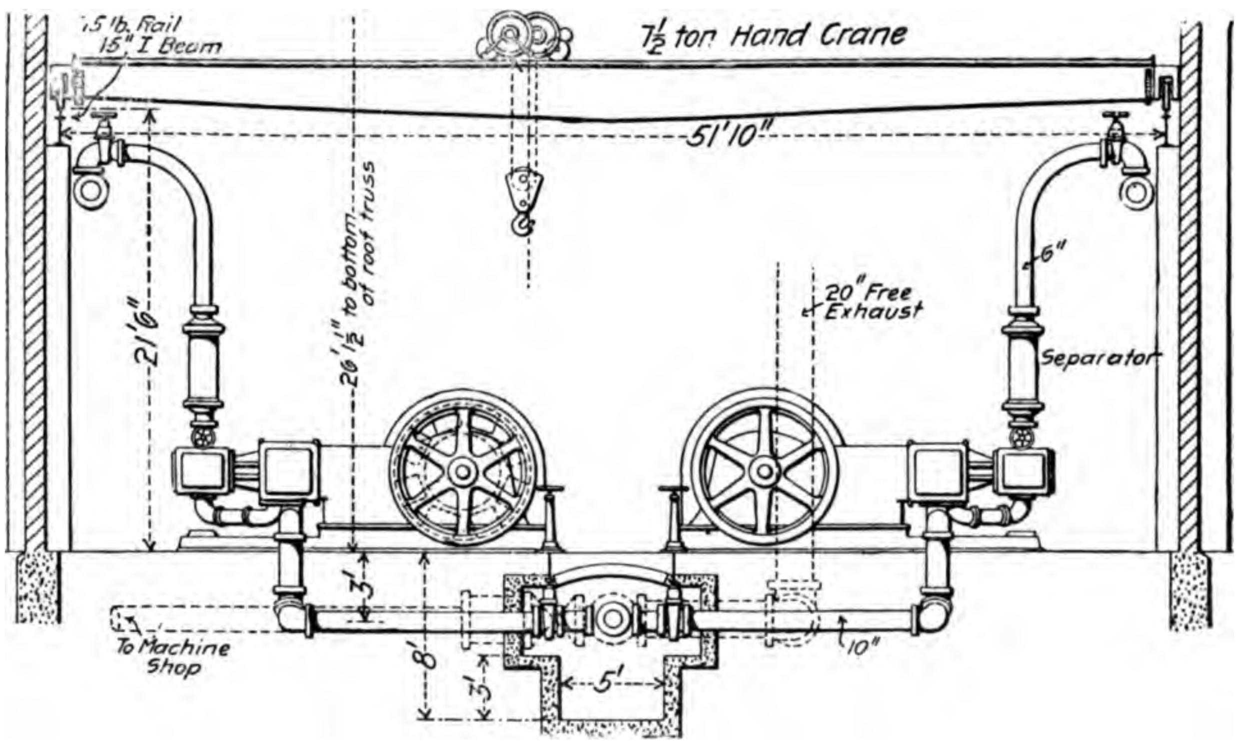
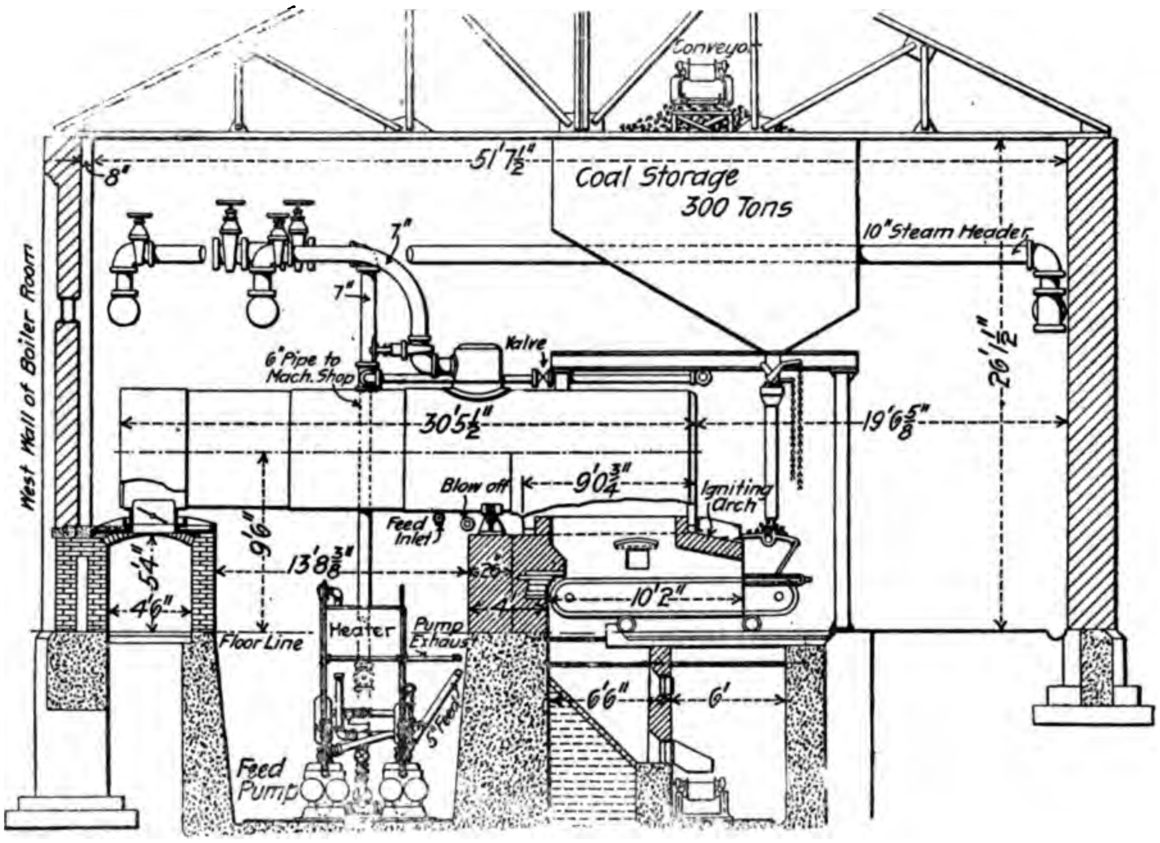


CROSS SECTION OF ENGINE ROOM IN POWER HOUSE AT TOPEKA, KAS., A. T. & S. F. RY.



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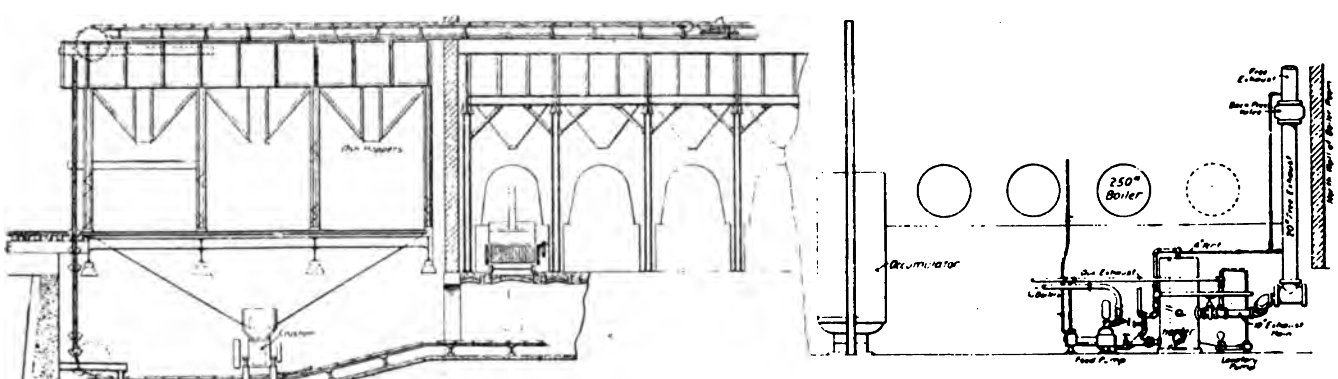
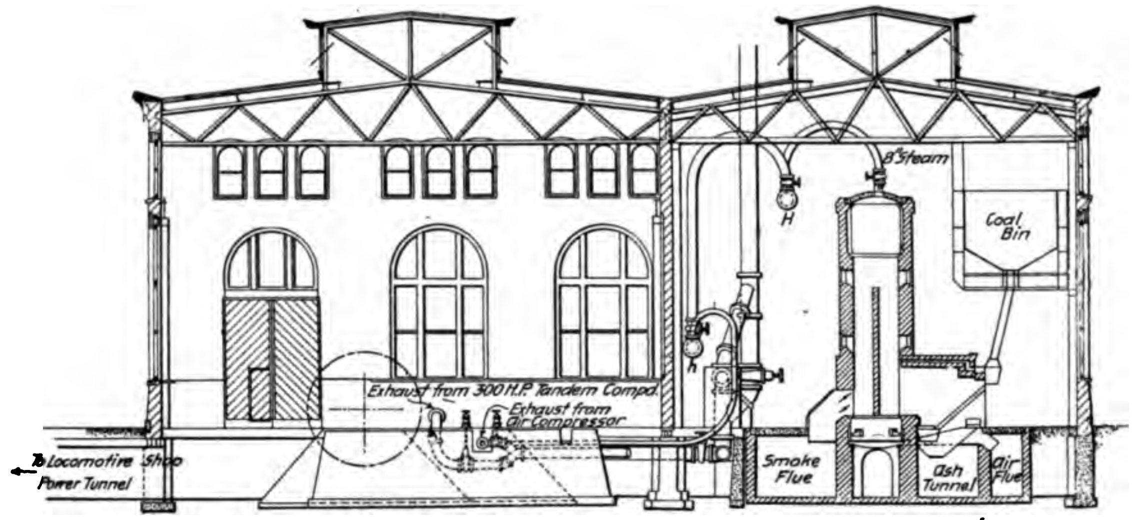
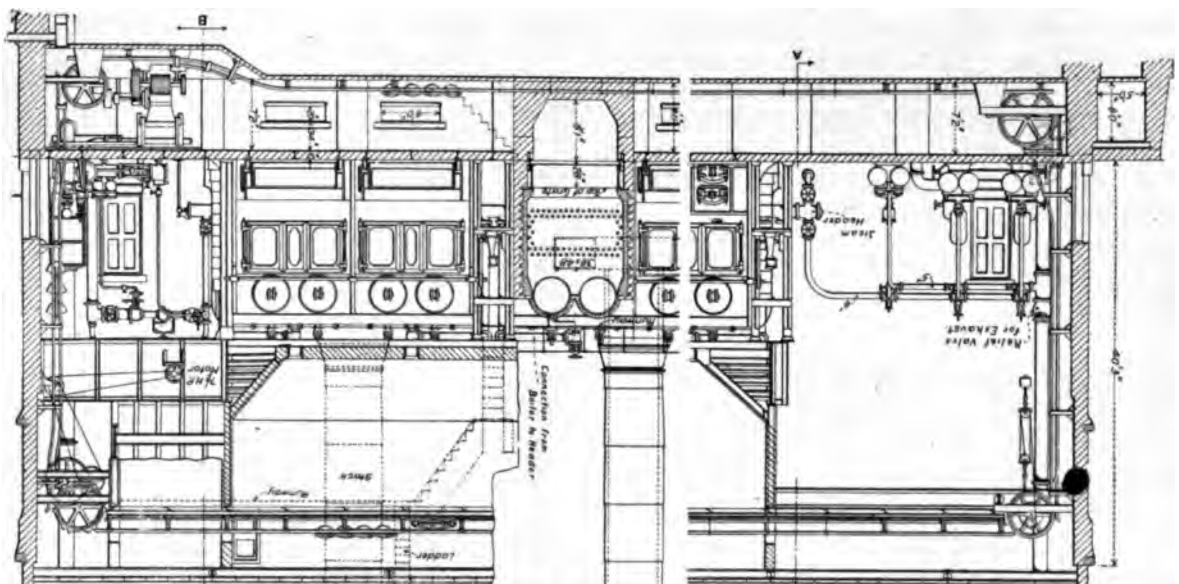


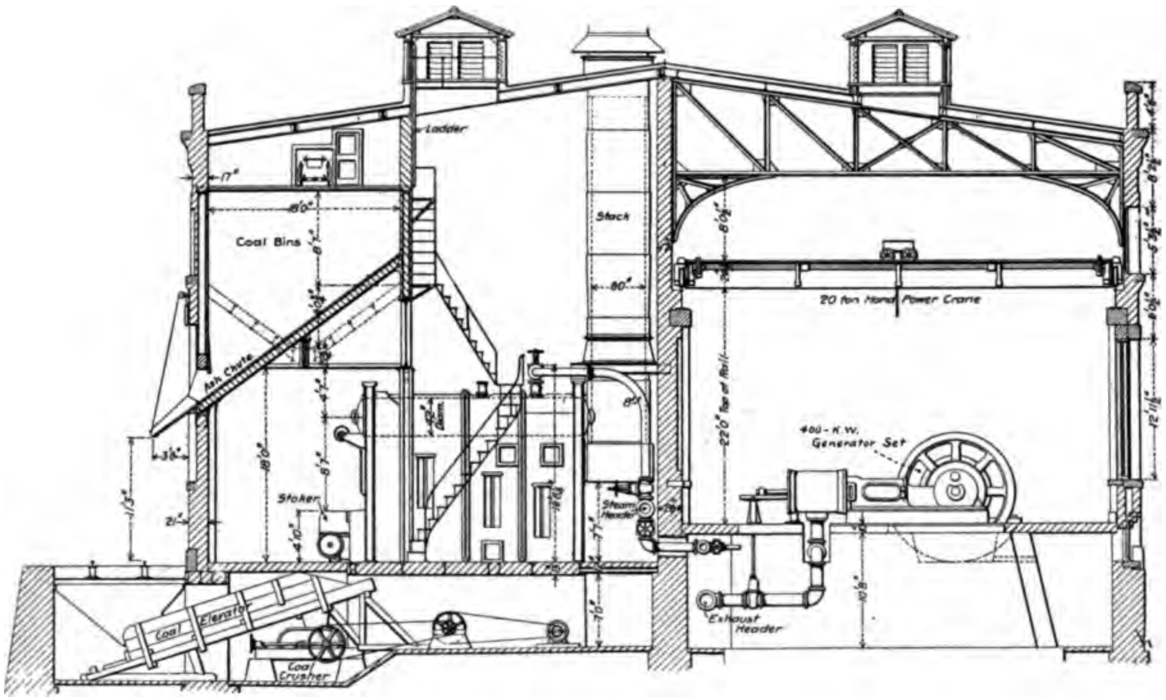
LONGITUDINAL SECTION OF BOILER ROOM AND COAL HOPPER PIT AT TOPEKA, KAS., A. T. & S. F. RY.



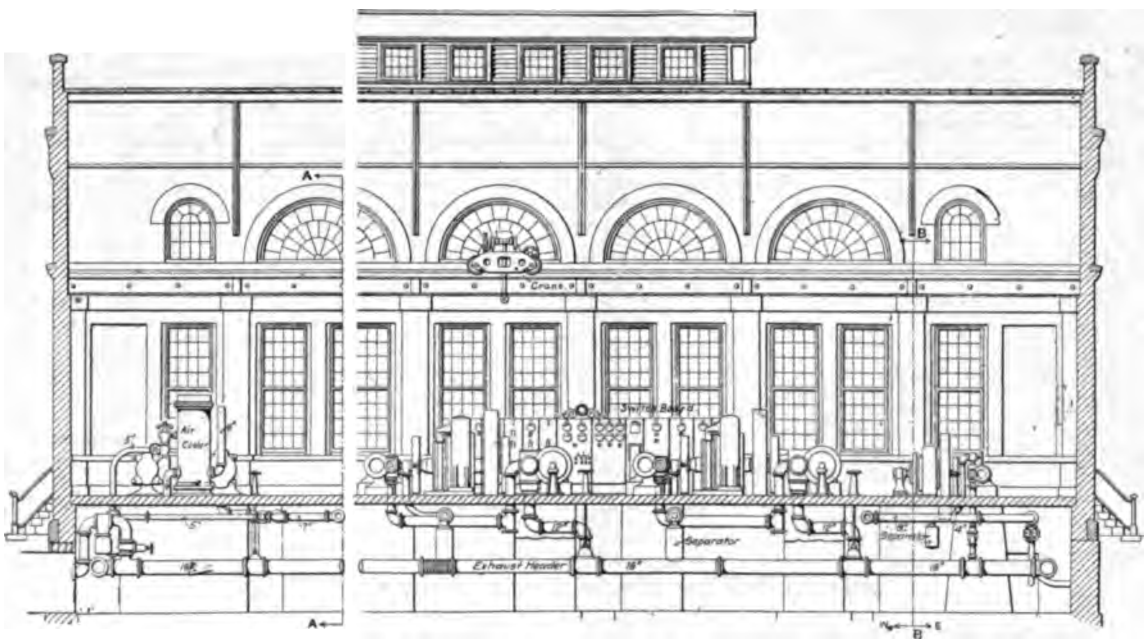
CROSS SECTION OF POWER HOUSE AT READING, PA., P. & R. RY.



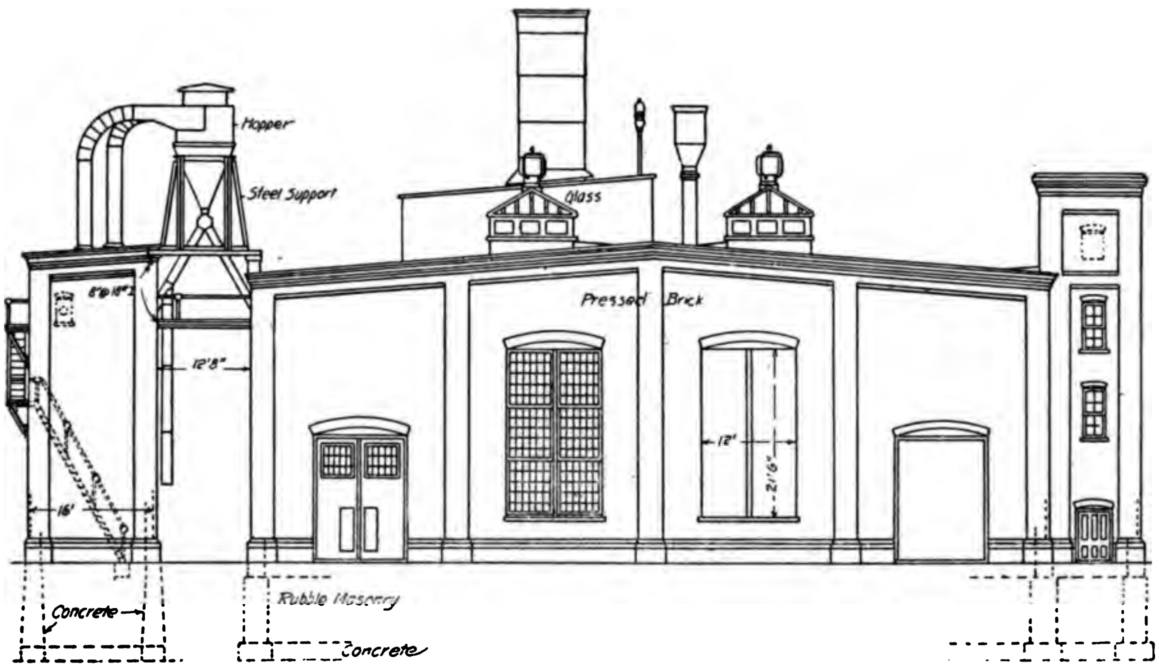
LONGITUDINAL SECTION THROUGH BOILER ROOM IN POWER HOUSE AT COLLINWOOD, O., L. S. & M. S. RY.



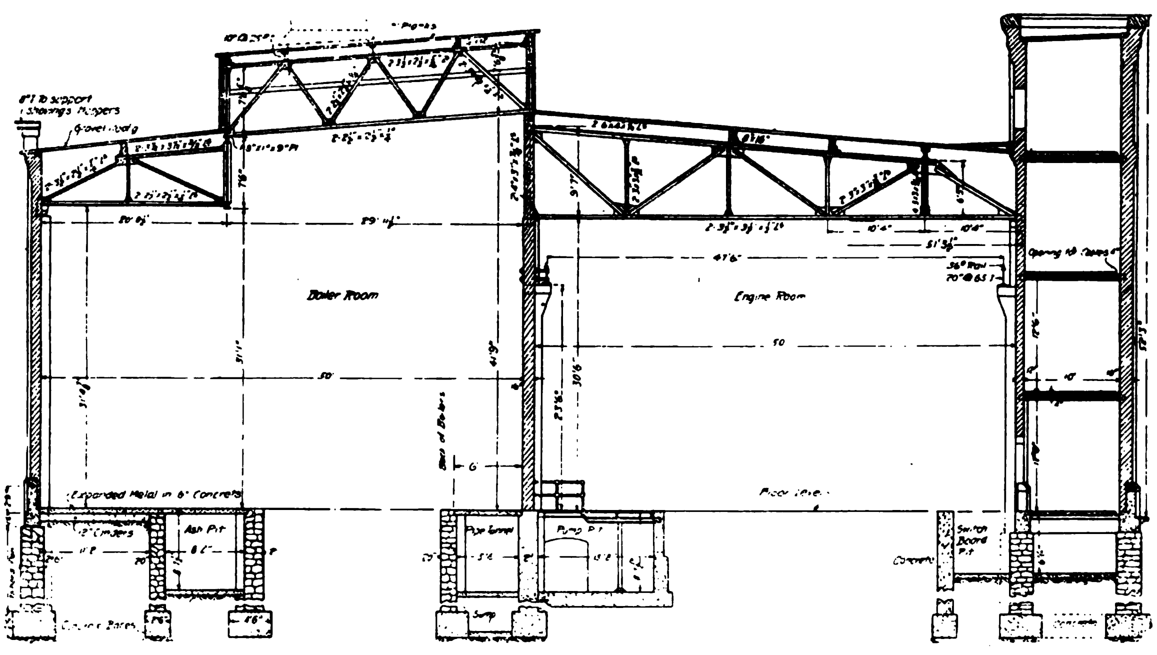
CROSS SECTION OF POWER HOUSE AT COLLINWOOD, O., L. S. & M. S. RY.



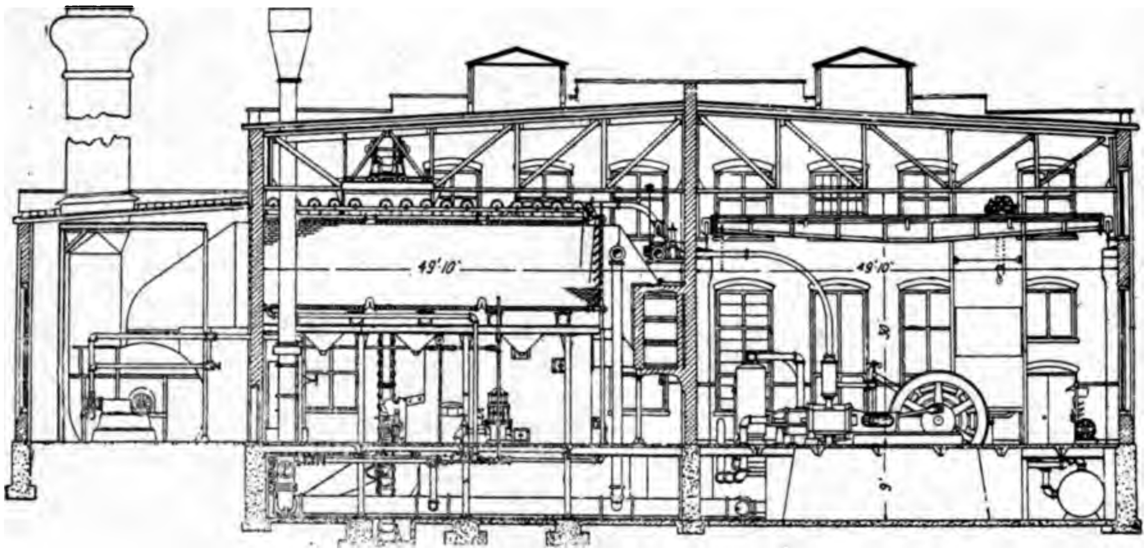
PARTIAL LONGITUDINAL SECTION OF POWER HOUSE AT COLLINWOOD, O., L. S. & M. S. RY.



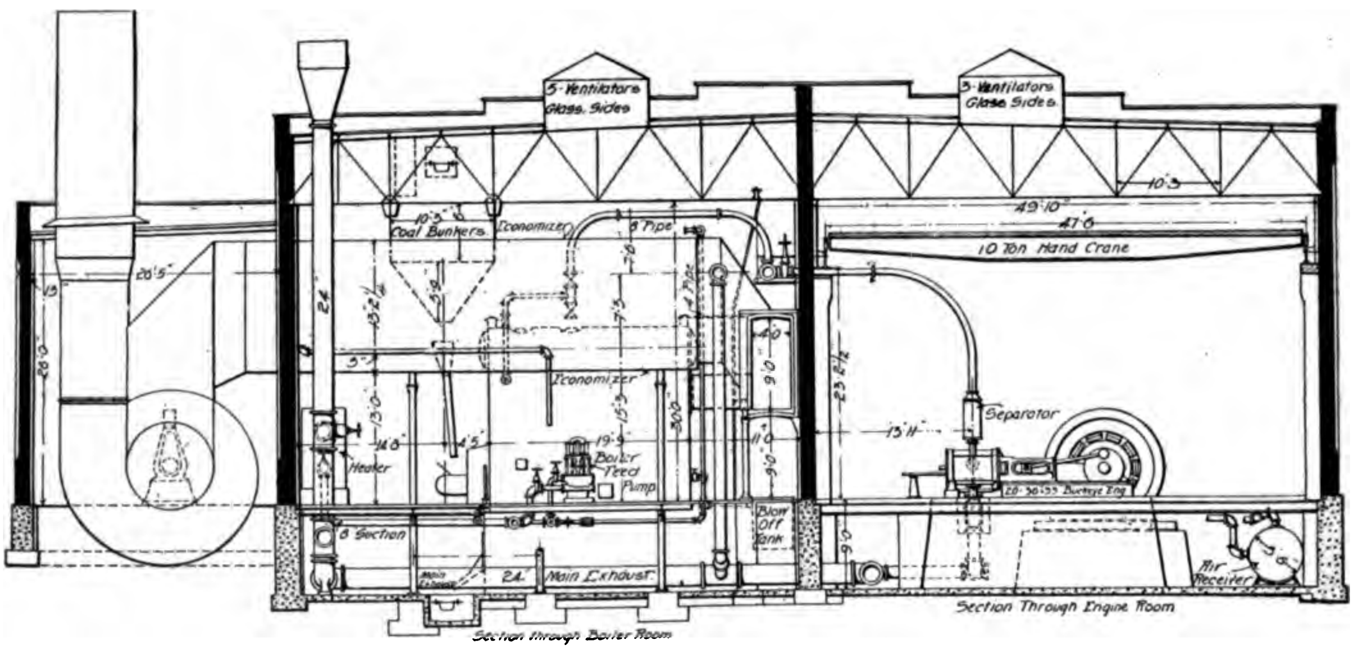
ELEVATION OF POWER HOUSE AT ANGUS (MONTREAL), C. P. RY.



CROSS SECTION OF POWER HOUSE AT ANGUS, C. P. RY.



CROSS SECTION OF POWER HOUSE AT SILVIS, ILL., C. R. I. & P. RY.



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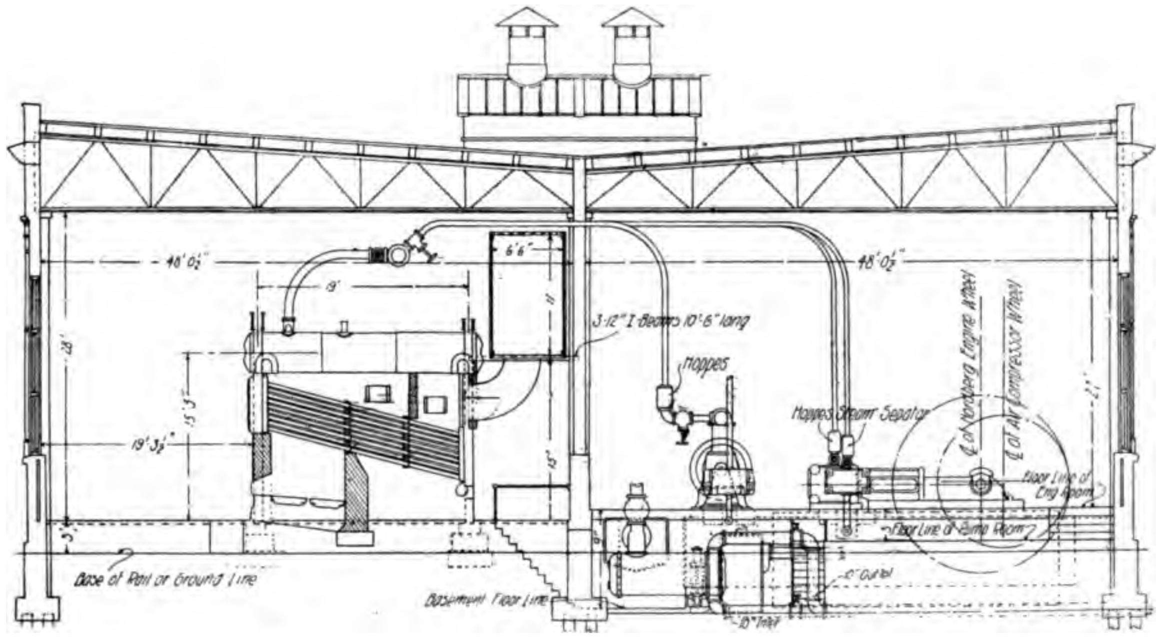
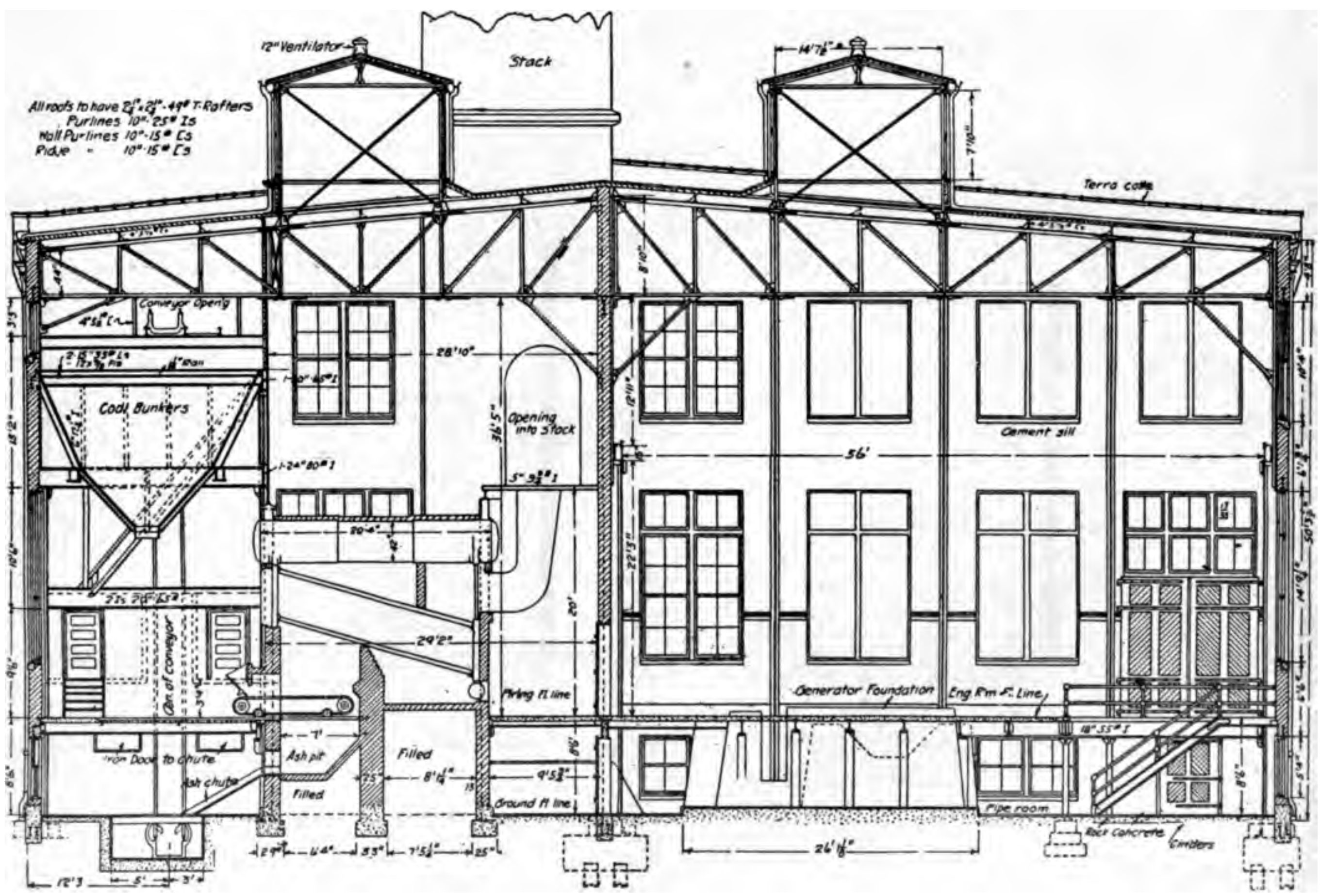
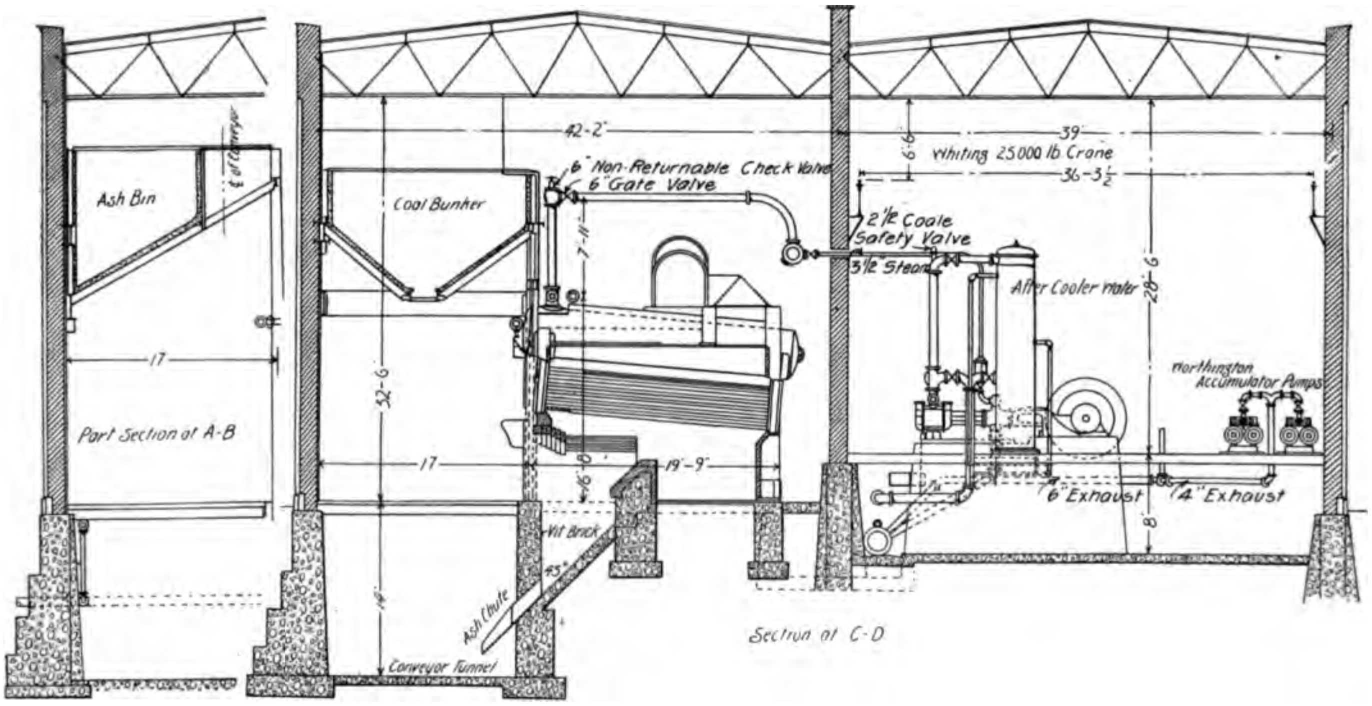


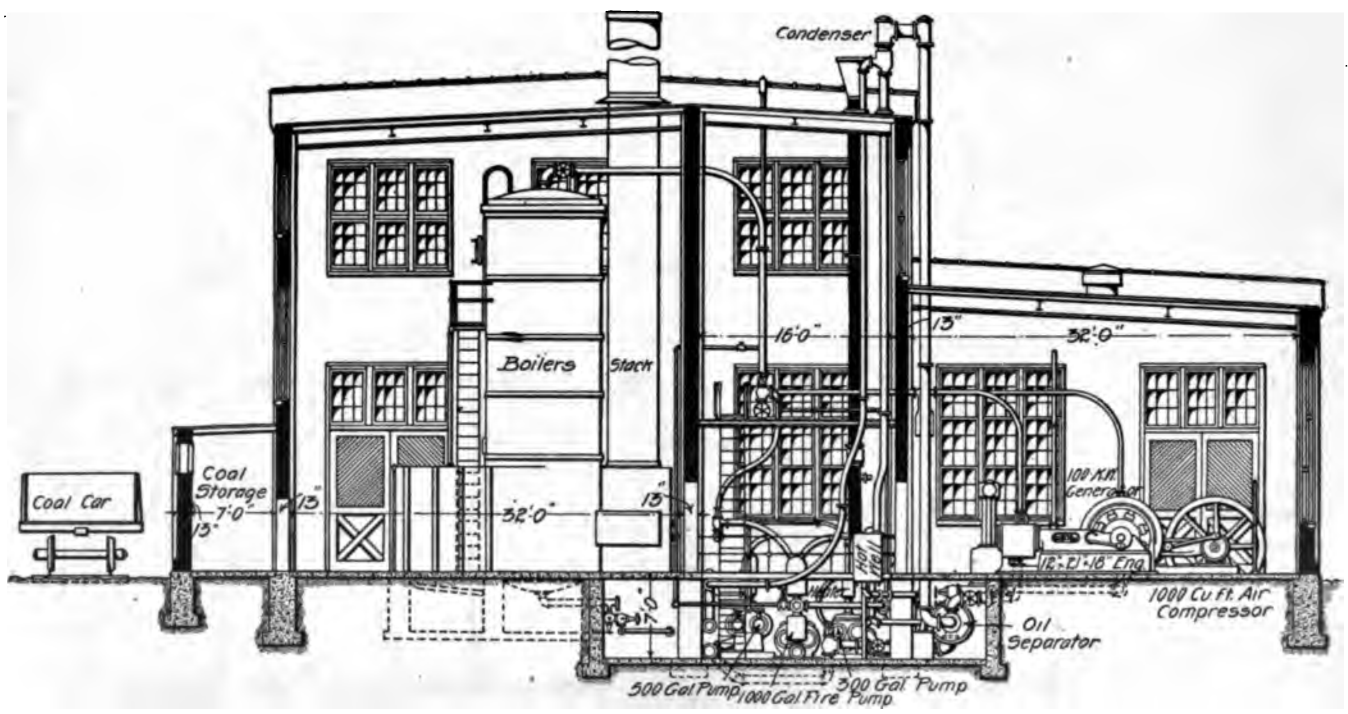
CROSS SECTION OF POWER HOUSE AT MILWAUKEE, WIS., C. M. & ST. P. RY.



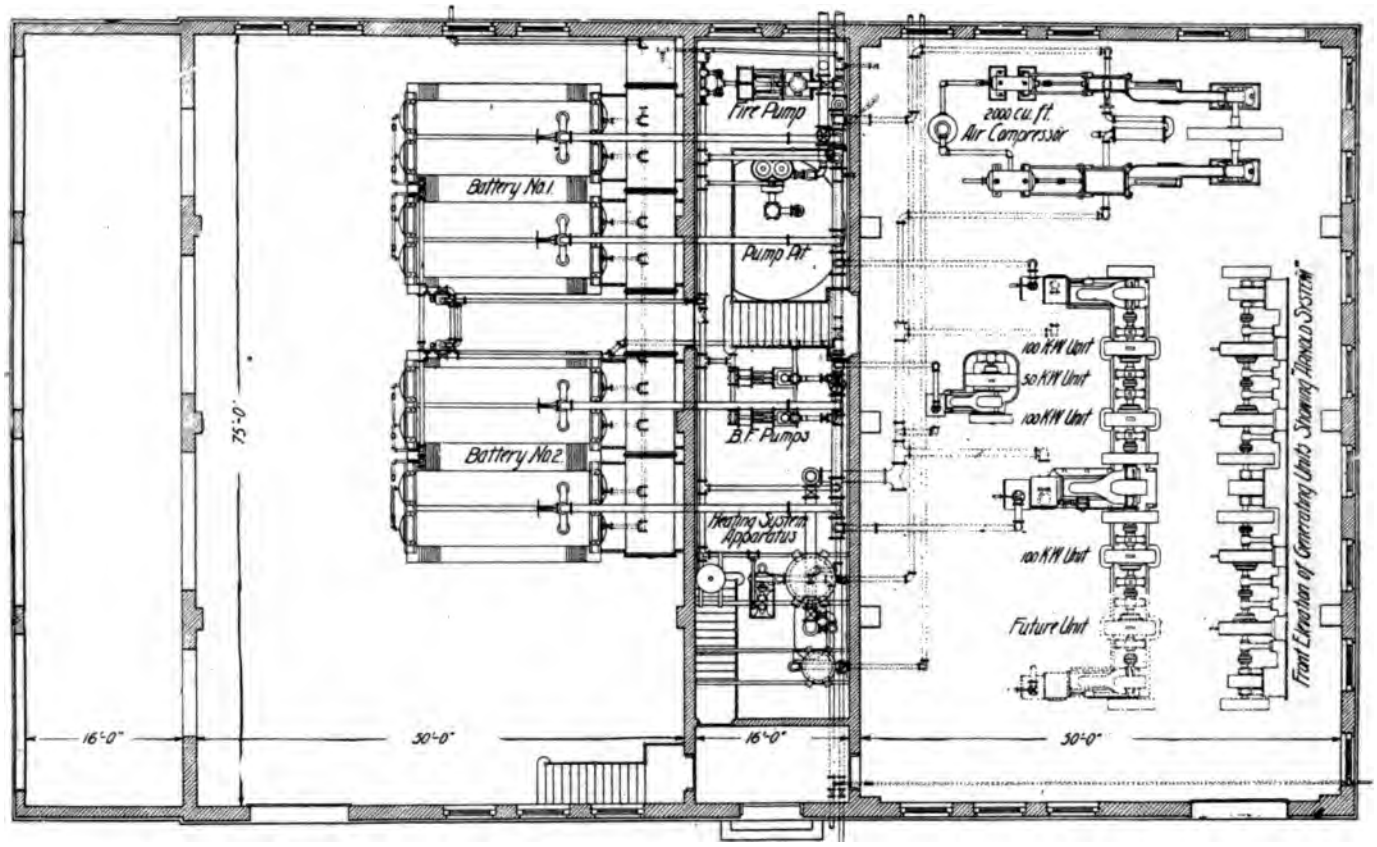
CROSS SECTION OF POWER HOUSE AT SOUTH LOUISVILLE, KY., L. & N. RY.



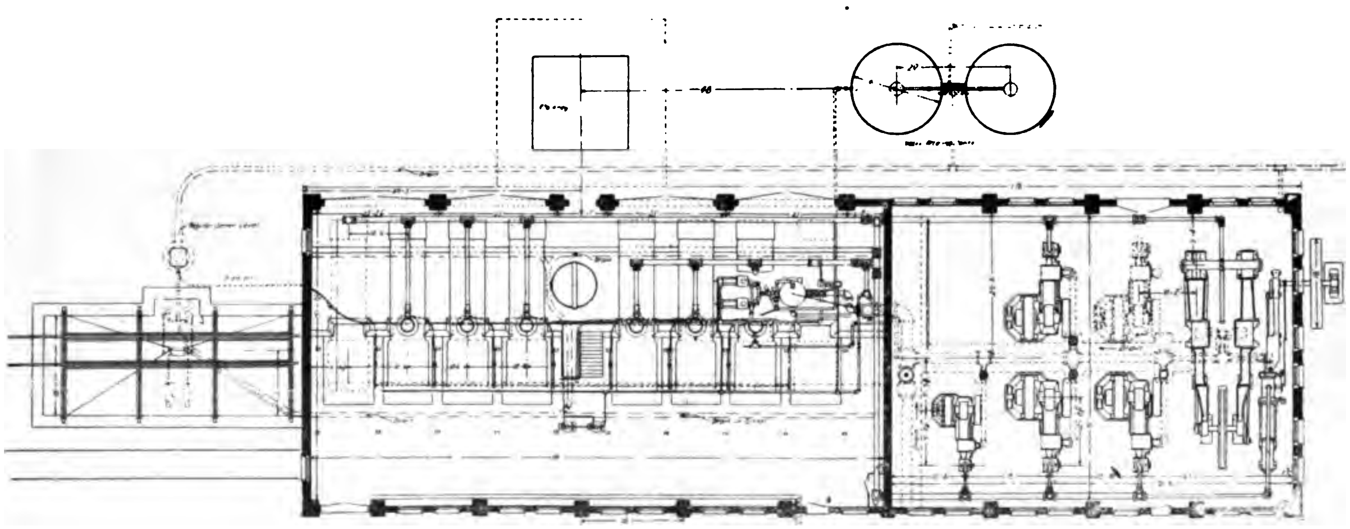
CROSS SECTION OF POWER HOUSE AT OLEAN, N. Y., P. R. R.



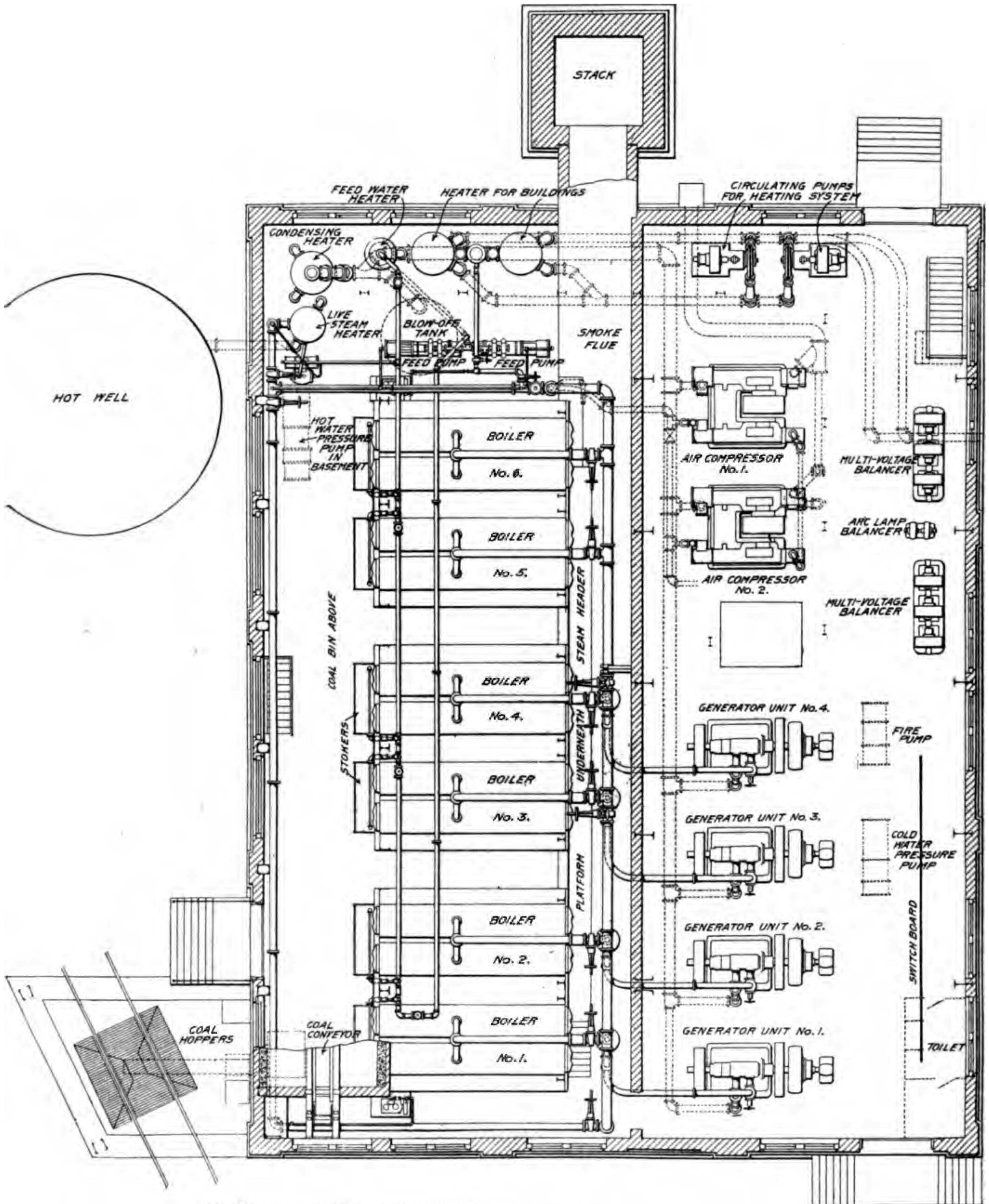
CROSS SECTION OF POWER HOUSE AT GRAND RAPIDS, MICH., PERE MARQUETTE R. R.



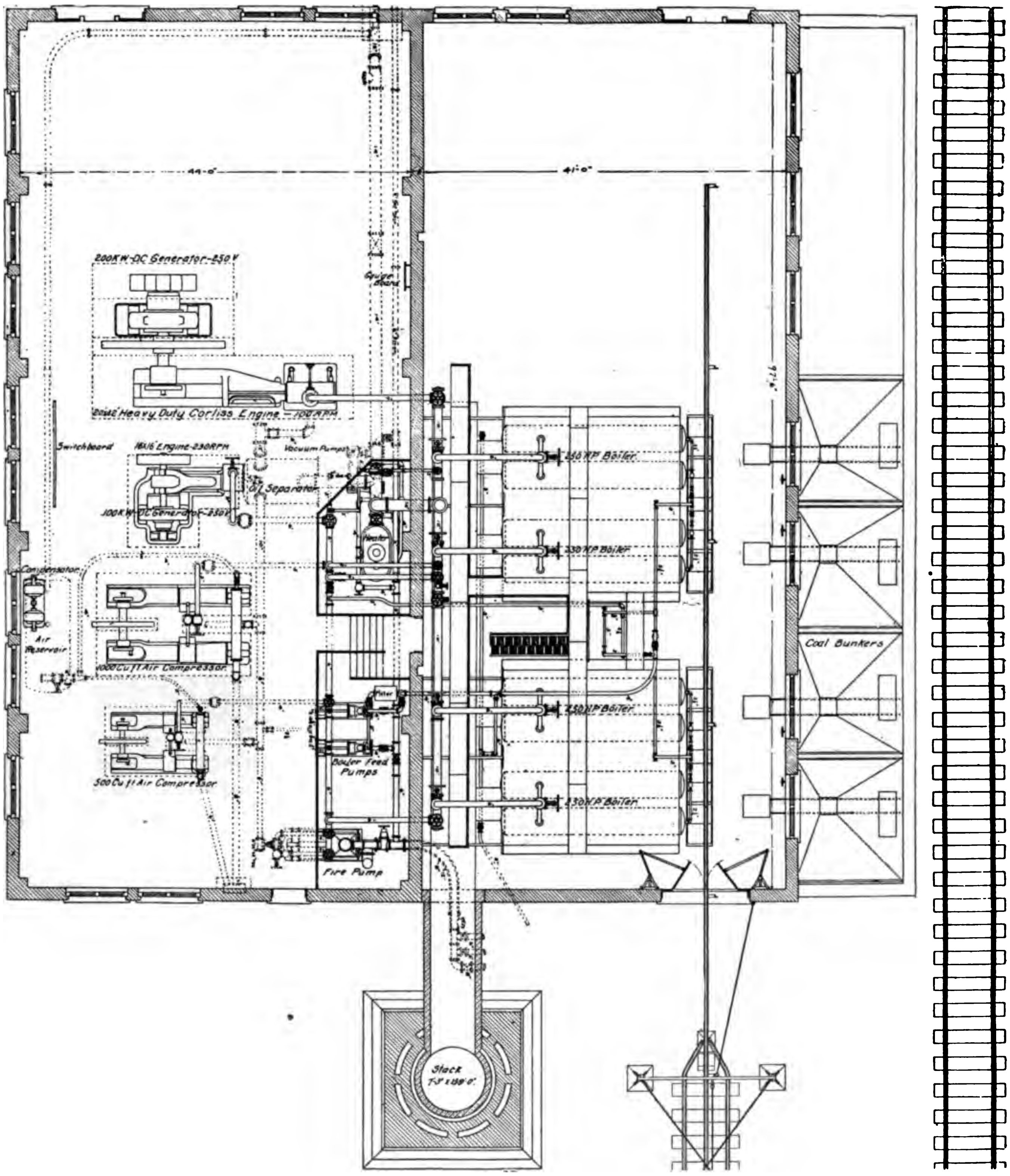
PLAN OF POWER HOUSE AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



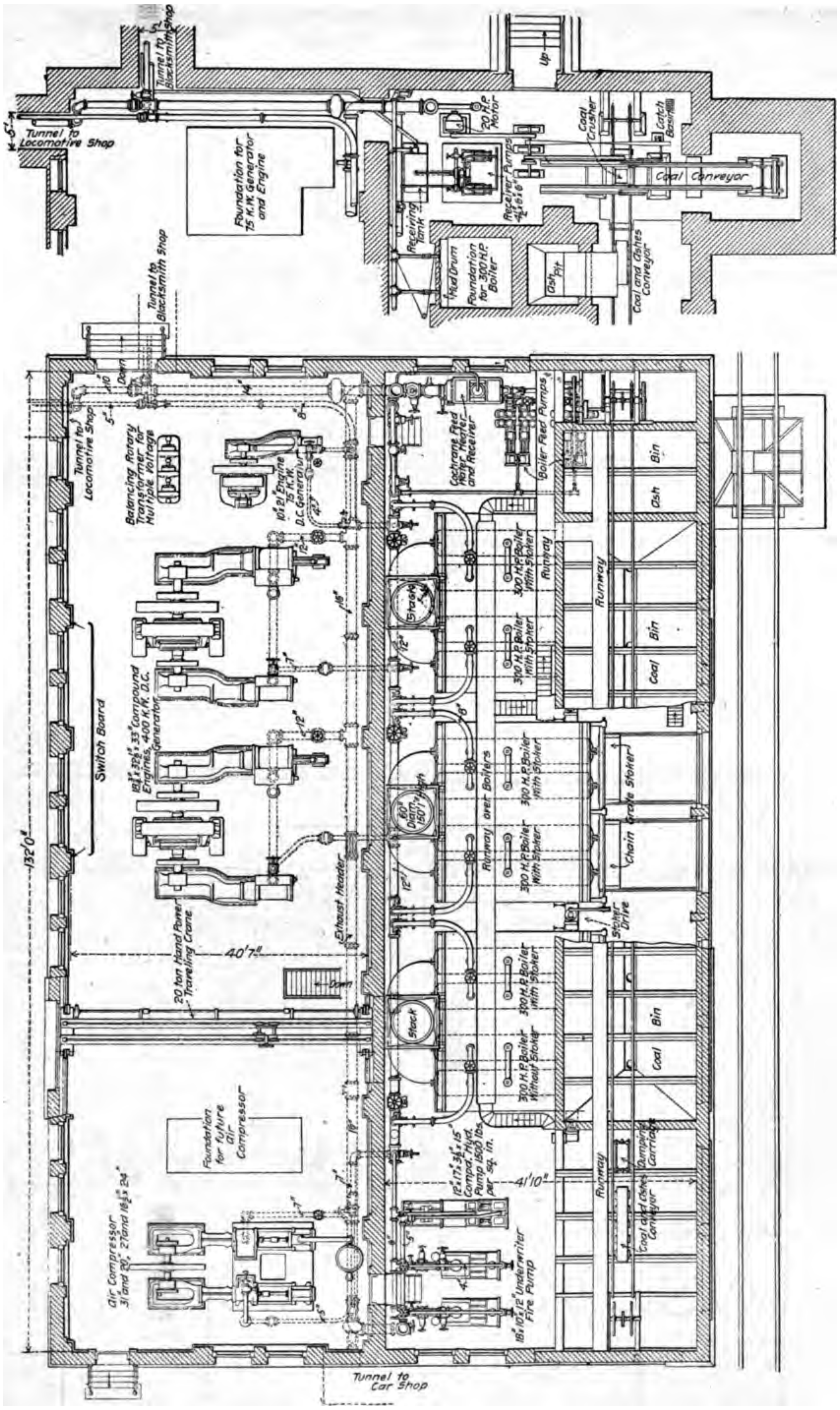
PLAN OF POWER HOUSE AT TOPEKA, KAS., A. T. & S. F. RY.



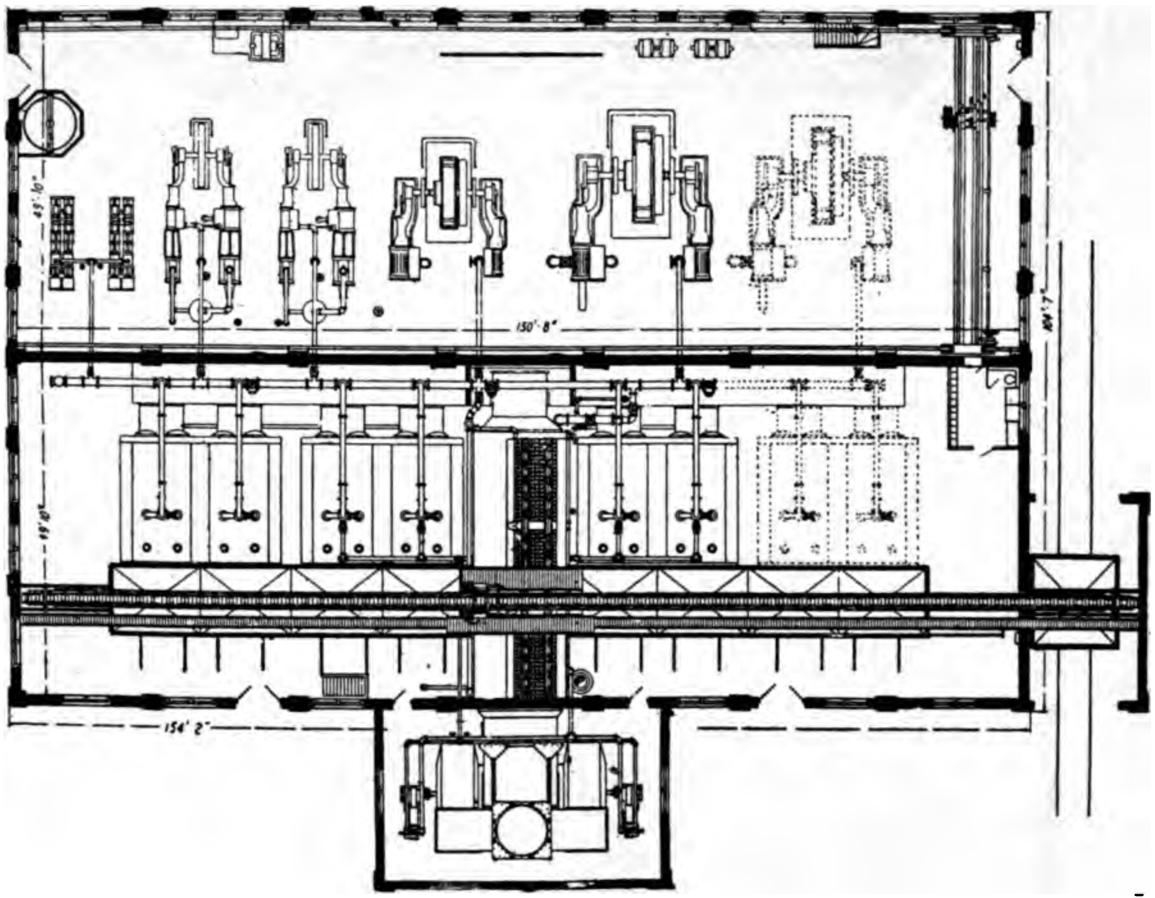
PLAN OF POWER HOUSE AT McKEES ROCKS, PA., P. & L. E. R. R.



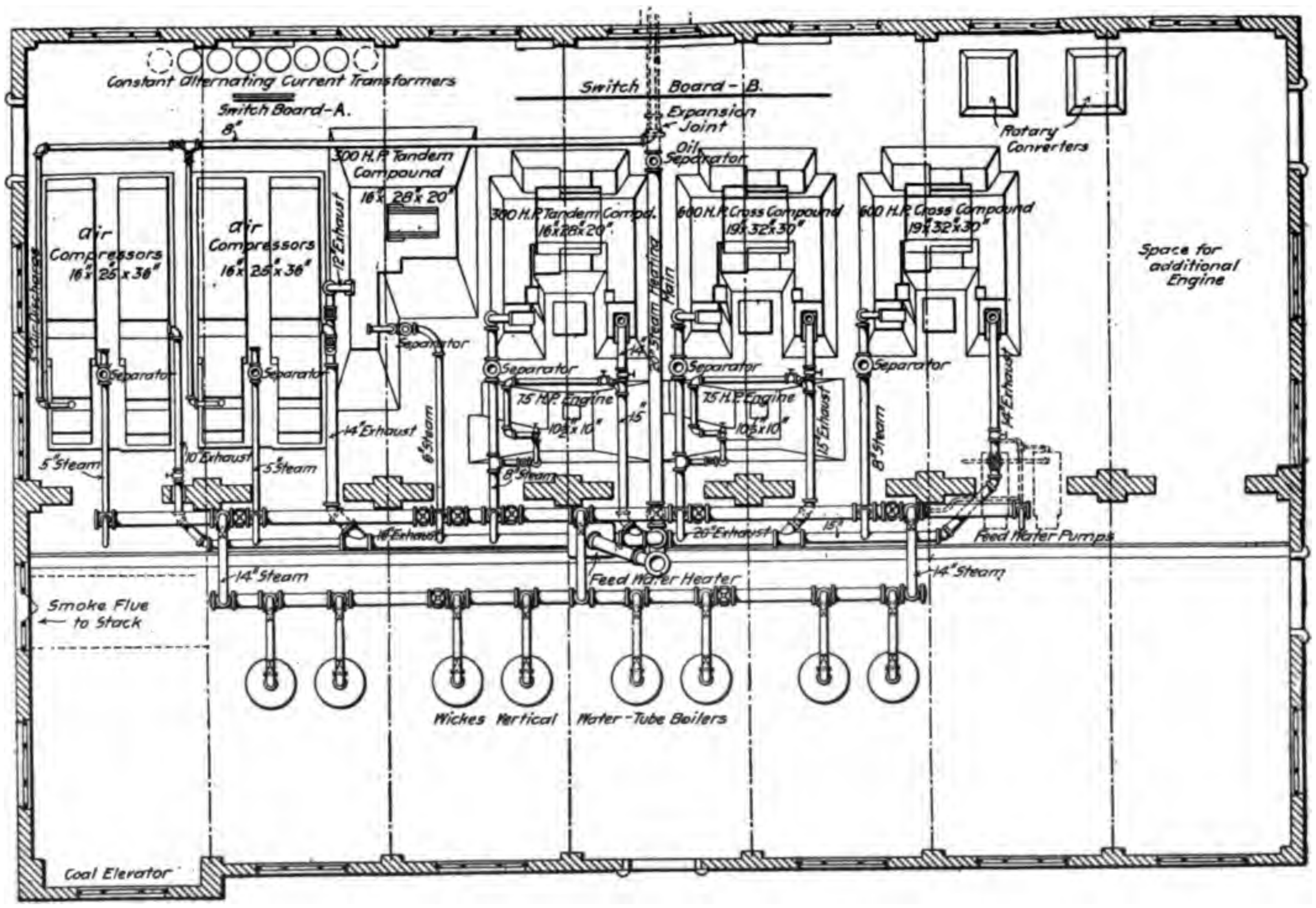
PLAN OF POWER HOUSE AT DANVILLE, ILL., C. & E. I. R. R.



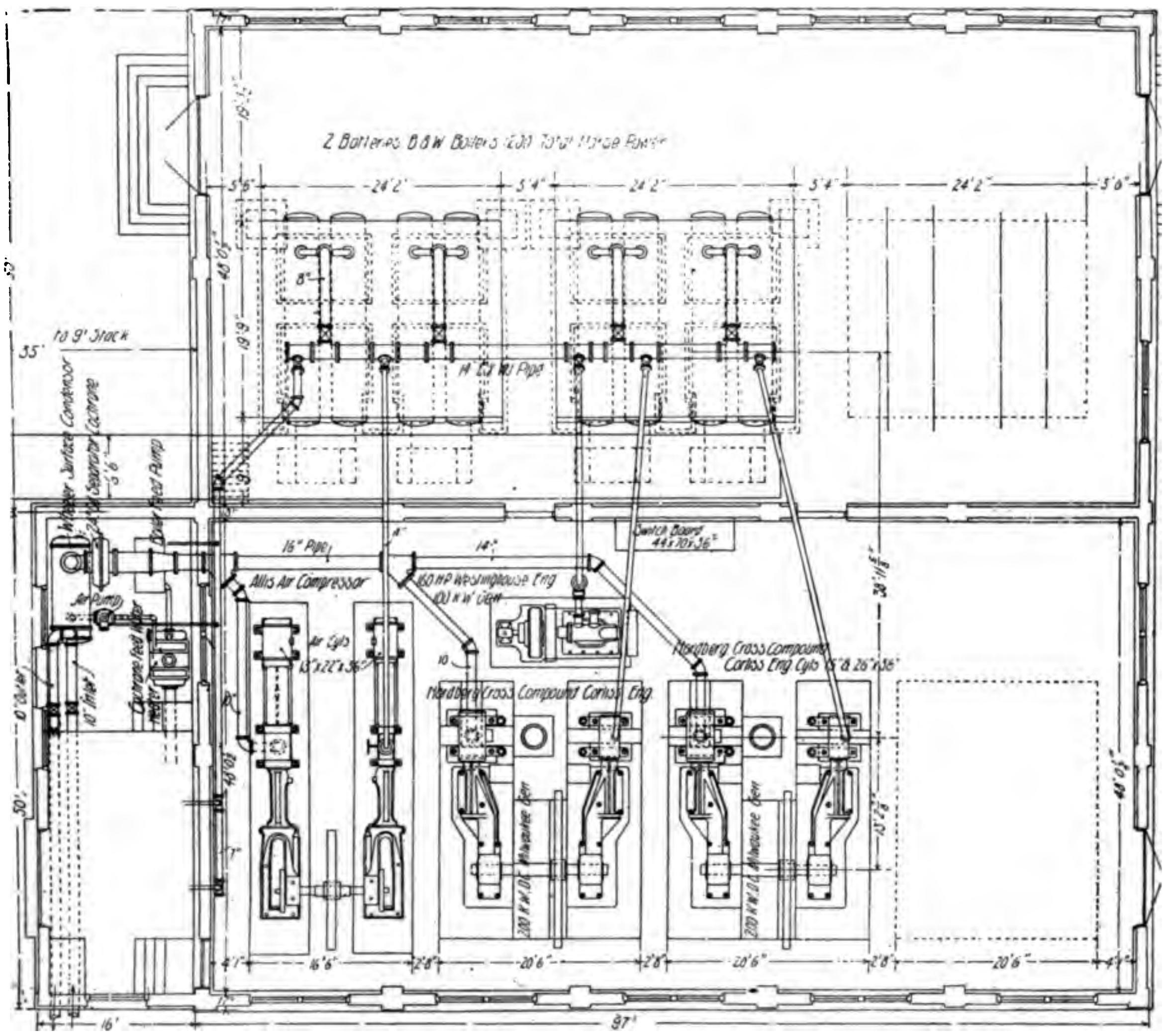
PLAN OF POWER HOUSE AT COLLINWOOD, O., L. S. & M. S. RY.



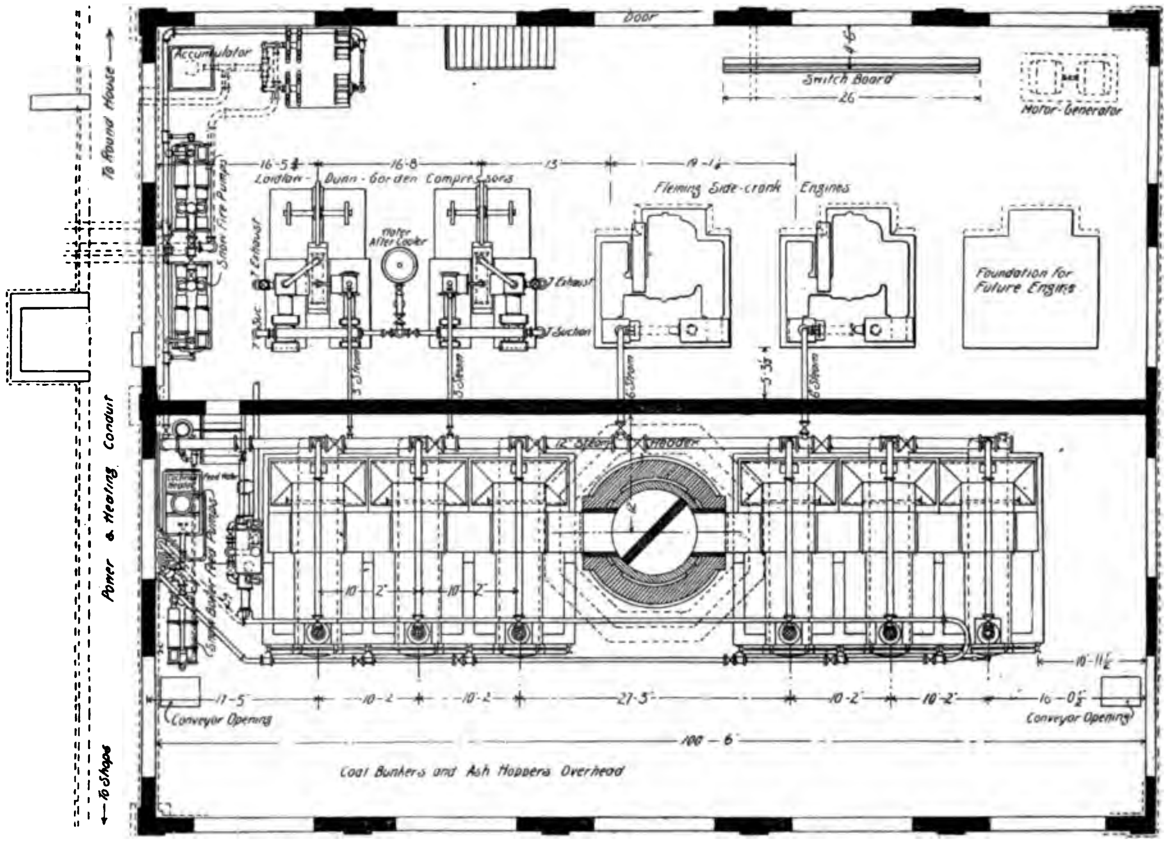
PLAN OF POWER HOUSE AT SILVIS, ILL., C. R. I. & P. RY.



PLAN OF POWER HOUSE AT READING, PA., P. & R. RY.



PLAN OF POWER HOUSE AT MILWAUKEE, WIS., C. M. & ST. P. RY.



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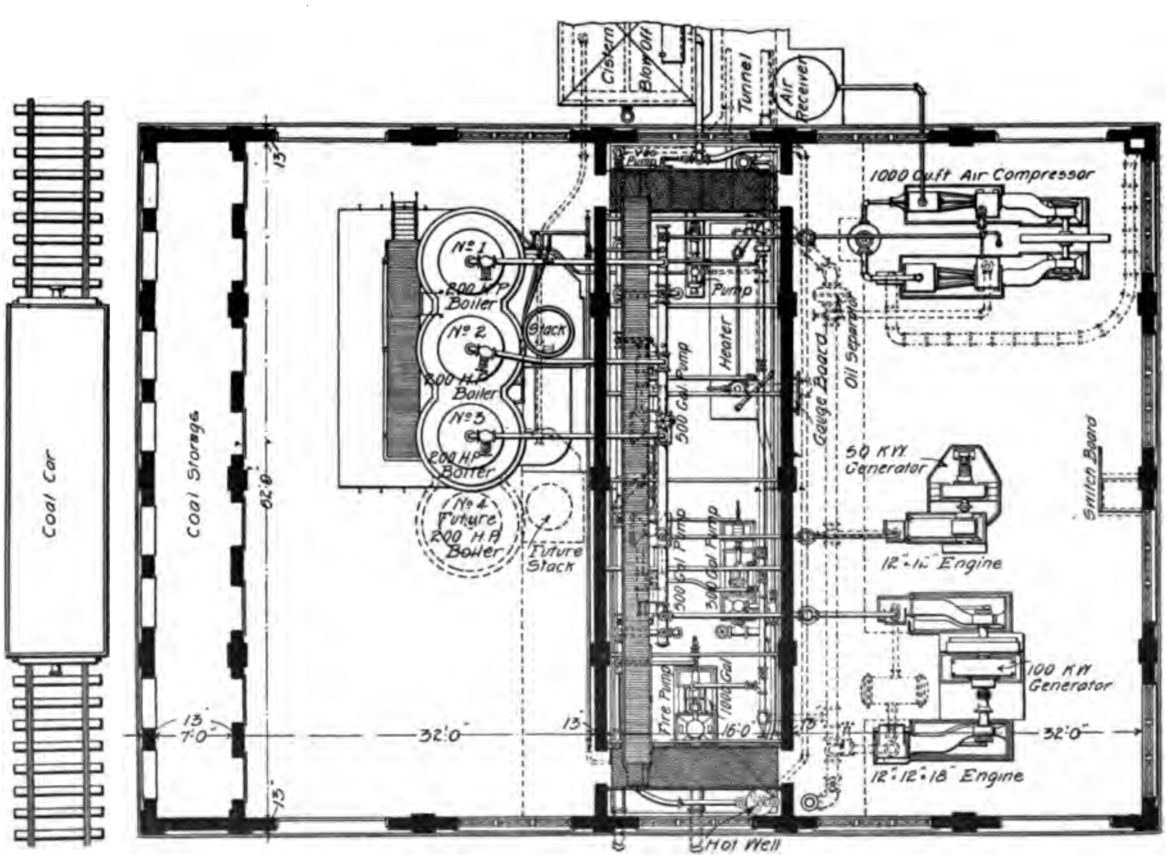


PLAN OF POWER HOUSE AT GRAND RAPIDS, MICH., PERE MARQUETTE R. R.

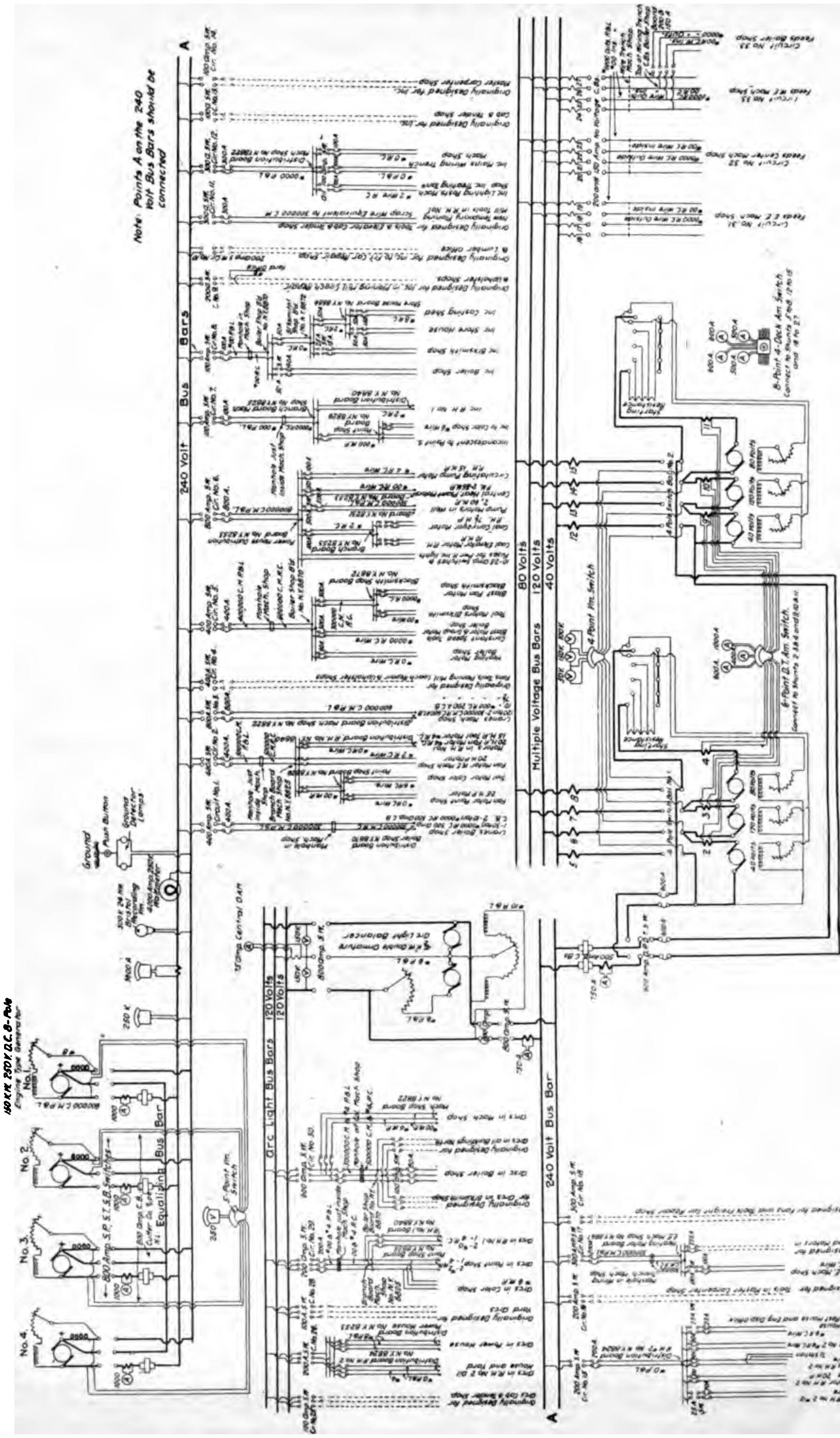


DIAGRAM SHOWING ELECTRICAL DISTRIBUTION OF POWER AT McKEES ROCKS, PA., P. & L. E. R. R

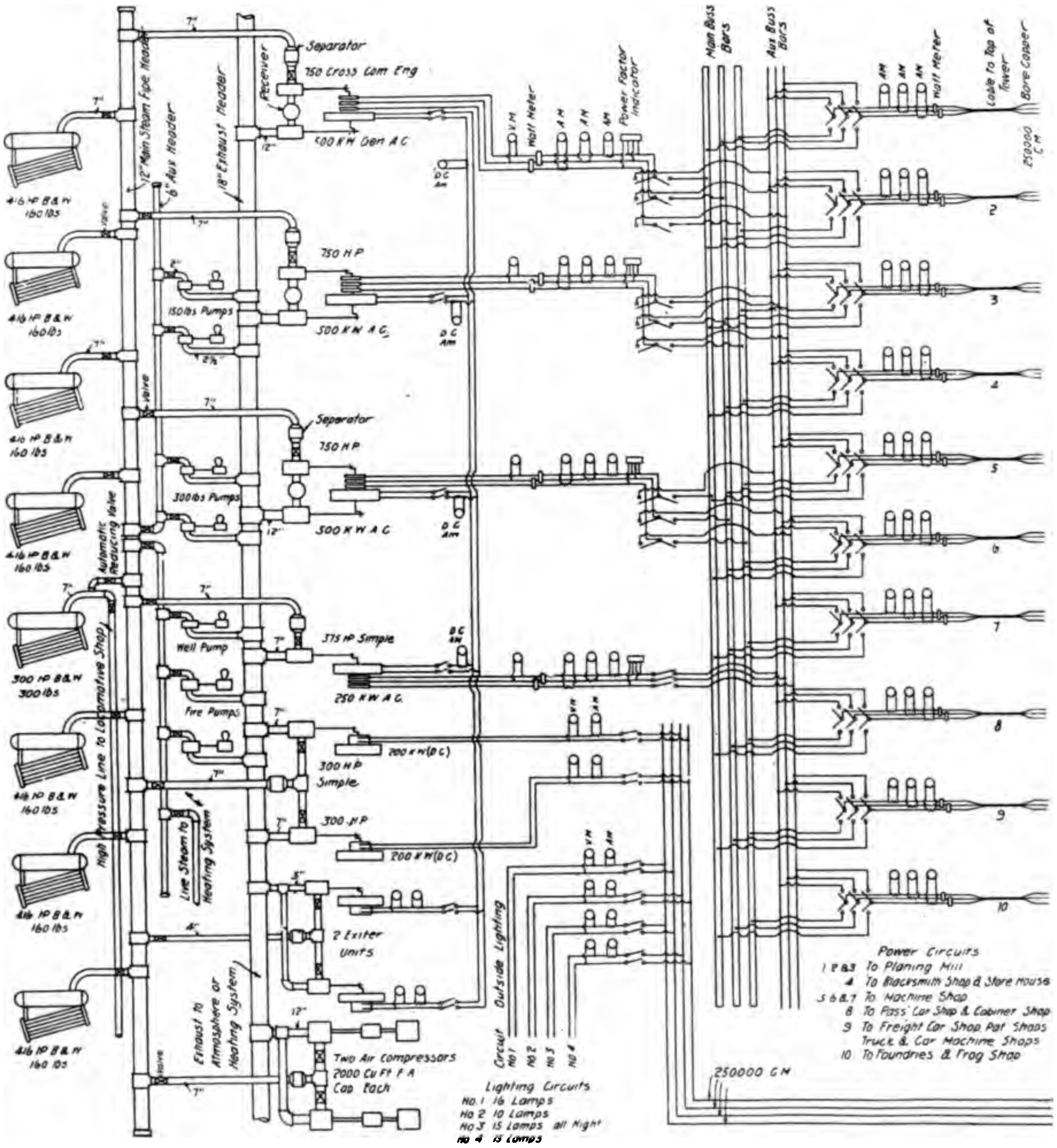
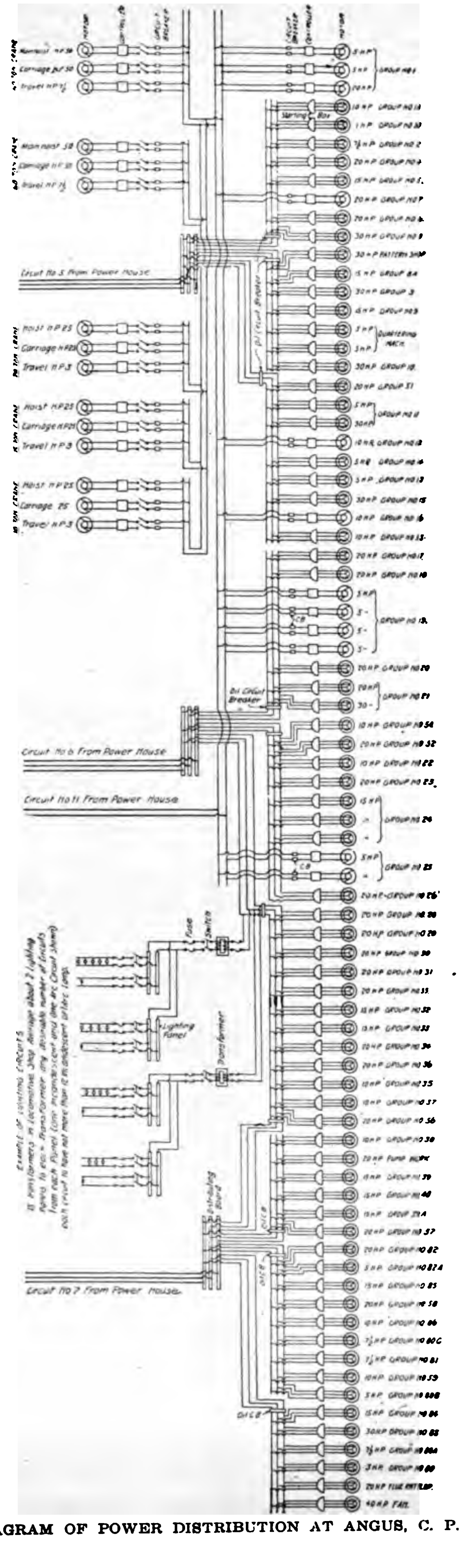


DIAGRAM OF POWER DISTRIBUTION AT ANGUS, C. P. RY.



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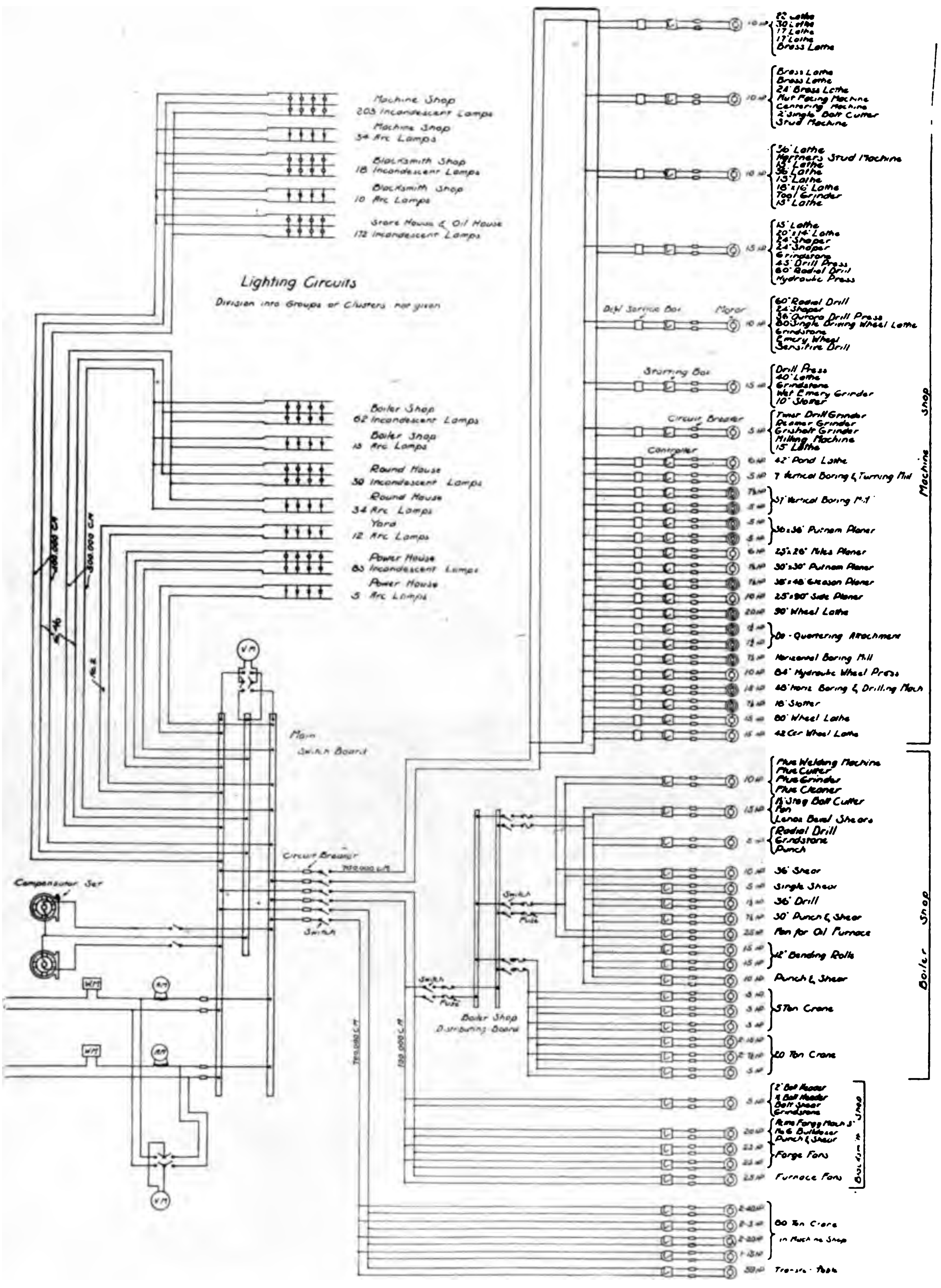


DIAGRAM OF POWER DISTRIBUTION AT DANVILLE, ILL., C. & E. I. R. R.

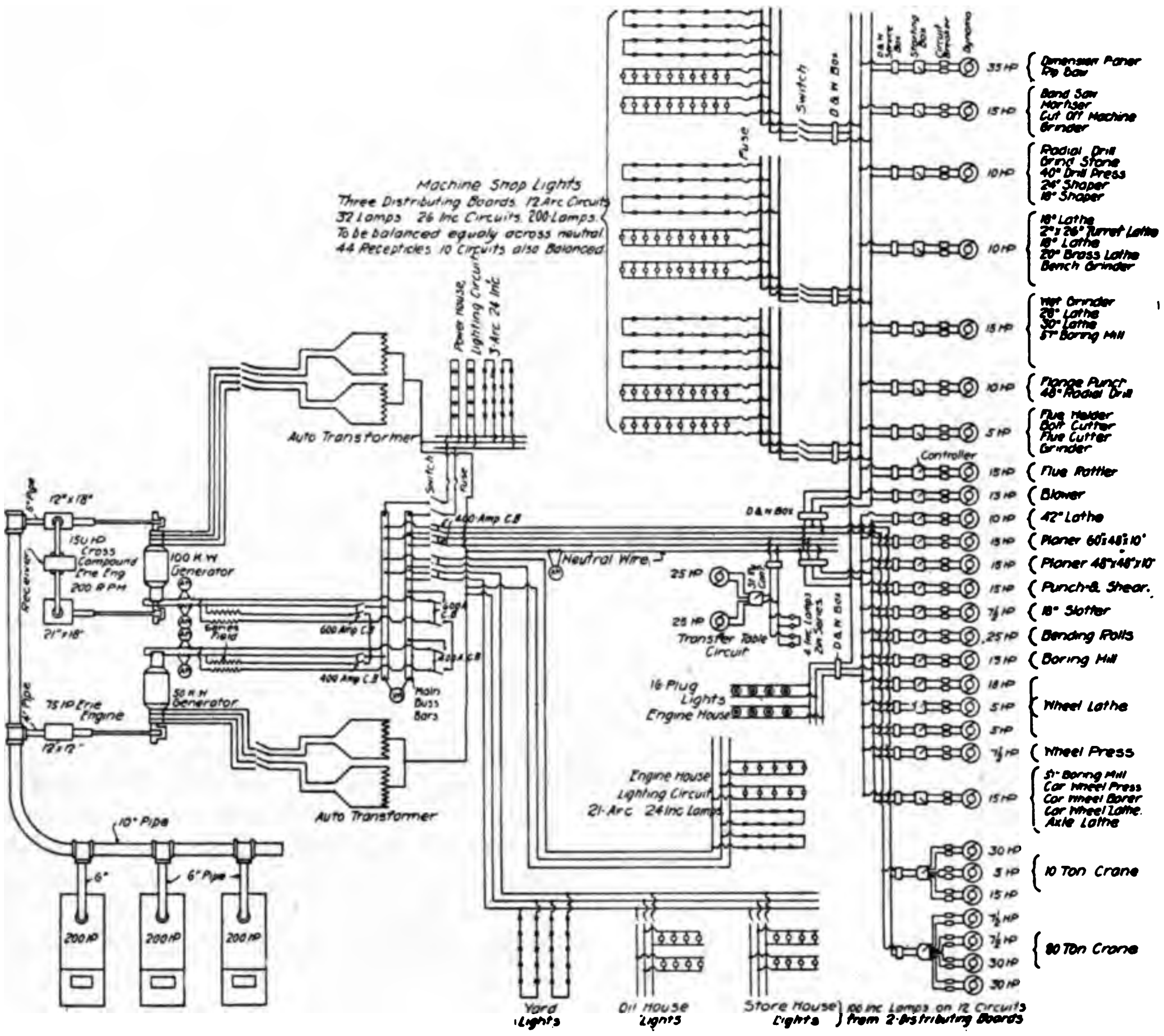


DIAGRAM OF POWER DISTRIBUTION AT GRAND RAPIDS, MICH., PERE MARQUETTE R. R.

Railway Shop Up To Date

Chapter XI.

STOREHOUSE

THE development of a large number of small railways into a comparatively small number of large railway systems has emphasized the importance of having an extensive base of supplies as a factor in the efficient and economical operation of the large system. The necessity of such a base has resulted in a well organized department in charge of the care and distribution of supplies and material, and the work of such organizations has done much toward decreasing operating expenses and providing for the prompt delivery of material.

As a result of the necessity of having a base of supplies, the general storehouse has been developed. It is usually situated at the principal center of the railway system and in connection with the general shop plant. The store department is now very commonly under the jurisdiction of a general storekeeper with headquarters at the point at which the general storehouse is located. From this point distribution is made to other points where local storehouses are maintained and supplies are delivered to the several departments.

A number of spacious, well designed storehouses have been constructed in connection with recent shop plants and proper facilities have been provided for sorting and delivering material, not only in the storehouse proper but also in the storage yards, which are now considered adjuncts of the general storehouse. There are several striking examples of railway shop managements working in close accord with the stores department, which illustrate the desirable results to be obtained by such cooperation. All new and manufactured material is received under the jurisdiction of the general storehouse and is stored, delivered and disbursed by this department.

The development of good facilities and the effective methods which have been introduced are due largely to the efforts of the Railway Storekeepers' Association. The indications are that much more is to be accomplished and doubtless future store departments will bear further evidence of the work of this association.

While the storehouse is an individual building the department which it governs contributes to nearly every part of the shop plant. Due to the size of much of the material used, it is impossible to store all material in the storehouse or on the platform adjoining the storehouse. Even if it were possible to store all the material in the storehouse, such a method would be impractical because of the additional cost entailed by the second or third handling of material. At a large shop, therefore, storage space is provided close to each building in which a large amount of material is assembled. This arranges for the storage of lumber, bar iron, boiler plate, flues, pipes, heavy castings, car wheels, tires, axles, truck frames, bolsters, etc. To handle this material economically requires outdoor traveling cranes, portable boom cranes, general yard tracks, as well as industrial track systems.

A very effective innovation in storehouse practice is the establishment of sub-stores in the several shops. In these sub-stores are kept material pertaining to the particular shop served which may be quickly replenished from the main storehouse. The economical feature of this method is that no time is lost by the workmen. All deliveries are made by representatives of the store department, and there is no excuse for a man to leave his work on the plea of going for material.

A diversity of opinion exists as to the advisability of establishing sub-stores about the plant, as the claim is made by some that the additional force required to look after them, together with the liability of excess of stock, more than offsets the expense of delivering material from the general storehouse to the different departments by special messenger.

The modern storehouse includes an up-to-date building and adjoining platform, together with large storage areas near the individual shop buildings, to take care of all material without crowding, as well as modern facilities for handling material. It also provides for system in the arrangement of material. Material is divided into sections according to class, in order that a laborer sent after a desired article can make no mistake in its selection, and in order that an inventory may be taken at the end of each month of all material in stock, without increasing the operating expenses or without increasing the cost of handling. Such system in providing for careful inventory at regular periods is an essential feature in assisting the store department to order intelligently and to keep stock down to a consistent minimum.

The orderly arrangement of material according to class calls for proper storage facilities in the yards as well as in the house. For instance, racks for standing boiler plate on edge to facilitate handling and to economize space; racks near the freight car erecting shop for storing and separating frame rods; bins for classifying castings; special boxes for classifying and stacking bolts, nuts, washers, etc.; iron storage racks and houses; proper shelving and pigeon holes to suit the various classes of small material, etc. An essential feature worthy of attention is a small compartment, carefully enclosed, for the storage of brass parts, which are frequently stolen if not thoroughly protected.

LOCATION.

As a general base of supplies for an entire railway system the location of the storehouse at the shop plant at which it is situated is such as to provide for good shipping facilities in order to expedite the rapid loading of cars for outside points. This requires good connections with the general yard system of tracks and with the outside lead. In some cases there is a single track on each side of the storehouse, in others there is a track on one side only, and in still others there are two tracks on each side.

While the storehouse may serve the entire system, or a single division, at the same time it is the center of distribution for the shop plant of which it forms a part. Its locaton to meet local requirements should be near the center of the plant and between the locomotive and car departments. There is usually a string of cars on one or both sides of the storehouse and more or less movement of these cars before or after loading and unloading. Where the storehouse is located centrally these cars offer some impediment to the distribution of material and movement between shop buildings.

In many shops of recent design, careful attention has been given to so arranging the individual shop buildings as to provide for intercommunication, and this arrangement is being improved by placing the principal buildings tributary to a general thoroughfare or avenue of shop traffic. Where this principle is followed, the storehouse is usually at one end of the thoroughfare and at one side of the area occupied by the shop buildings. According to this scheme track connections to the storehouse are convenient and the general thoroughfare provides for distribution to the locomotive and car departments with equal facility. In this respect there is a certain similarity between the general layout plan of the large shops recently constructed, in which the principal buildings are tributary to a crane served midway, and that of the smaller shops in which the principal buildings are tributary to a single transfer table. In one, the storehouse is at the end of the midway and in the other it is at the end of the transfer table pit.

This feature is exemplified rather strikingly by the illustrations presented in connection with the chapter on the railway shop layout, selected as representative of a number of practical shop arrangements.

At Burnside, I. C. R. R., and at Collinwood, L. S. & M. S. Ry., the storehouse is between the locomotive and car departments. At Silvis, C., R. I. & P. Ry., the car department has not yet been built, however, the storehouse is so located as to be between the present site of the locomotive department and the site selected for the car department.

At Angus, C. P. Ry.; Beech Grove, C. C. C. & St. L. Ry.; Battle Creek, Grand Trunk Ry., and at Scranton, D. L. & W. Ry., shops at which the principal buildings are arranged tributary to a crane served midway, the storehouse is adjacent to this thoroughfare and at or near the edge of the property covered by shop buildings.

At Denver, C. & S. Ry.; Hannibal, C. B. & Q. Ry.; Oelwein, C. G. W. Ry., and at Fond du Lac, Wis. Cent. Ry., where the principal buildings are tributary to a single transfer table, and at South Louisville, L. & N. R. R., where the principal buildings are tributary to a single transfer table and a crane served storage yard, making an L-shaped thoroughfare, the storehouse is located at one end of the transfer table pit.

BUILDING.

The storehouse is usually in an isolated building where there is ample room for track approach and for surrounding the building, partially or in whole, with a storage and unloading platform. In more recent years this principle has been adhered to almost without exception in building new shops. However, there are a number of shops now in service in which the storehouse is a part of the main building or has walls in common with some of the other buildings. At Oelwein, C. G. W. Ry., the storehouse is at one end of the main building, and the storehouse at Reading, P. & R. R. R., is between the boiler shop and blacksmith shop, having walls common with both.

The nature of the service performed by the storehouse requires a large amount of loading and unloading. It is therefore essential that provision be made for a number of cars to stand at the storehouse at one time and that trucking across the house shall cover a short distance. For this reason the storehouse is a long narrow building.

For greater facility in loading and unloading cars the first floor of the storehouse is usually 4 feet above grade or at the level of an ordinary box car floor. A platform usually extends along one or both sides of the first floor, and this platform is normally unobstructed in order to facilitate rapid trucking between the storehouse and cars. At each end there is usually a platform for the storage of such material as may be exposed to the weather without serious deterioration.

In view of the large amount of material which may be exposed to the weather and yet should be stored near the storehouse where it may be properly supervised, the tendency is for a wider platform along the sides of the building to serve as a storage space as well as a loading platform. Many store department officials consider 14 feet as the minimum width advisable, and a platform 18 feet wide is favored.

At Angus, C. P. Ry., the track approach and loading platform are at one side only of the storehouse. Doors on the other side are used for the receipt of material delivered by teams. As the storehouse at Reading is not isolated it is impossible to provide track approaches at either side, and the delivery track is brought in through the center of the building.

While the storehouse at Sayre, L. V. R. R., is isolated and has a track approach on each side, a delivery track is brought in through the center of the building. As the floor and platform are at the height of a car floor, the middle track causes a pit through the center. Access between the two sections thus formed is by means of adjustable bridges which are swung in the clear when cars are to be moved. The floor of the storehouse at McKees Rocks, P. & L. E. R. R., is on the ground level. This is flanked on each side by a depressed track and the cars are thus lowered to a convenient height.

The storehouse is usually a substantial building with brick walls in which the roof and upper floors are supported by a wooden structure of slow-burning construction. It is characteristic of modern storehouses that they are well provided with ample natural light.

There is quite a difference in the number and arrangement of floors at various storehouses. For instance, at Silvis. C., R. I. & P. Ry., there are three floors, all above ground level. The floors are served by two electric elevators of 5,000 lbs. capacity each. At Collinwood, L. S. & M. S. Ry., the number and arrangement of floors are the same, and the three floors are served by a single elevator of 5,000 lbs. capacity. The general storehouse at Burnside, I. C. R. R., has two floors above ground level in addition to a basement. The basement and two upper floors are served by an hydraulic elevator of 10,000 lbs. capacity, and in addition to this the basement is served by two hydraulic elevators of 10,000 lbs. capacity, each, which deliver direct to the shipping platforms along the sides of the building. The basement extends beneath the area covered by the side platforms, and thus has the advantage of this greater area in addition to that covered by the building proper.

The storehouse at Angus, C. P. Ry., is of one story, with the exception of a gallery for the storage of light material, which covers about two-thirds of the floor area. The gallery is reached by a single staircase and the clerical force of the stores department occupies offices at one end of the gallery.

A number of storehouses are of one story throughout, or of one story with a basement, and it is quite common to build the main portion of the storehouse of one story, with two or three stories at one end which are occupied by the storekeeper, the master mechanic and their respective office staffs.

While the storehouse at Angus covers a greater actual ground area than any other storehouse of which information is at hand, the storehouse at Silvis has the greatest storage space, due to the greater number of available floors. The Angus storehouse is 600 feet long by 85 feet wide, covering a ground area of 51,000 square feet, and providing a storage area of approximately 80,000 square feet. The Silvis storehouse is 500 feet long by 100 wide, covering a ground area of 50,000 square feet, and providing a storage area of 134,312 square feet, arranged with 47,712 square feet on the first floor and 43,300 square feet on each of the second and third floors. The clear heights above the first floor of the Silvis storehouse is about 18 feet, above the second floor about 14 feet, and above the third floor an average of a little over 9 feet. The Burnside general storehouse is 300 feet long by 70 feet wide, covering a ground area of 21,000 square feet and providing a storage space of 61,600 square feet. In addition to this there is a new storehouse at Burnside which takes care of road department supplies, etc., and is 400 feet long by 72 feet wide, a portion 150 feet long being two stories high. The two storehouses cover a ground area of 50,400 square feet and provide a total storage area of 104,400 square feet. The storehouse at Collinwood is 302 feet long by 60 feet wide, covering a ground area of 18,000 square feet and providing a total storage space of 54,000 square feet. The one-story storehouse of the Lehigh Valley Railroad at Sayre is 363 feet long by 102 feet wide and provides a storage space of 37,400 square feet.

INTERIOR ARRANGEMENT.

The interior arrangement of the storehouse with regard to the distribution of storage shelves, cases, racks, etc., like so many features of a railway shop plan, depends on local conditions. The conditions peculiar to this case are the shape and size of building, location of windows or skylights providing natural light, and the number of floors in the storehouse.

The shelves and bins are commonly arranged in large sections and the sections so placed as to form long aisles extending the entire length of the building to provide for the delivery and distribution of material. A feature of importance almost equal to that of providing for unimpeded delivery is the arrangement of sections to allow the unobstructed diffusion of natural light. Another essential feature is the arrangement of aisles and sections so that the officer in charge of the storehouse may obtain a view covering a large area from one vantage point.

The experience of a number of different storehouses would lead to the conclusion that where the building is a long narrow structure of a single story and natural light is almost wholly admitted through skylights in the roof, the most satisfactory arrangement of shelves and bins is in long rows parallel with the length of the building, with aisles between for trucking and distribution. With such an arrangement the entire floor is well lighted naturally and is subjected to easy observation from an office at one end of the floor. Further, the capacity of the floor is well utilized for storage space.

Where the floor is entirely dependent upon windows in the wall for natural lighting, the cross arrangement of shelves seems to give the best results, longitudinal aisles being provided for trucking and distribution. Some storehouse authorities maintain that all windows in the walls should be at least 10 or

12 feet above the floor line to allow the wall space to be utilized for bins, shelves, etc.

The windows in the side walls of the storehouse at Angus, C. P. Ry., are 12 feet above the floor in order that storage shelves may be arranged along these walls and yet allow generous natural light. In addition to those shelves at the side are sections of shelves arranged transversely. Four longitudinal aisles traverse the area occupied by the shelves, one in front of each side row and two passing through the cross sections. There are no dark or dusty corners in this building, and anyone walking along the aisles has a clear and unobstructed view of the alley ways between the racks.

The Angus storehouse is divided into three sections separated by fire walls and fireproof doors. The sections are designated as A, B and C. Section A occupies the end of the building nearer the locomotive shop and is used for the storage of material common to the locomotive department. For similar reasons car material is kept in Section C. Section B is called the shipping section and through it is handled current material for the line. This section is provided with three receiving and three distributing doors. There is a scale and office at each door and all material entering and leaving the storehouse is weighed and checked.

The individual sections and shelves at most railway storehouses are usually built of wood and designed according to the requirements of local conditions and for the specific material to be stored. The portion constituting the base is usually wider than the upper portion and is of the same width for a height of about three feet. Above this the shelves usually taper toward the top, and the wider portion of the base section provides a narrow platform on which to stand in reaching the upper shelves. The upper pigeon holes are usually small and the spaces become wider and higher until they approach the bottom.

The shelves and furnishings are necessarily provided in ample quantity and suitably designed to accommodate the great variety that constitutes the stock. It has been customary to accomplish this result by erecting permanent shelves and racks. In view of the number of changes that take place in the movement and rearrangement of stock, it has been suggested as desirable to equip store rooms with shelves and racks that could be extended, contracted or relocated without loss or inconvenience. This result may be accomplished to a great extent by adopting what is known as the unit system, that is, to build storehouse furniture in units, and of a size that would render them portable and interchangeable. While the outside dimensions of these units must be uniform they should be of various designs, suited for the different classes for which they are required. The unit idea of construction finds its most conspicuous exemplification in the elastic book cases which are now being largely manufactured and sold.

Units suitable for storehouse practice have been built of ⅞ inch pine, 26 inches high, 52 inches long and 16 inches deep outside. These can be subdivided into sections as required. The sections should be raised a suitable distance from the floor, which may be done by resting them on a base built of 2 by 6 inch stock. A moulding may be placed on the top to give them a more finished appearance, but this is not necessary. As many units may be assembled as required and as space permits.

CRANE SERVICE.

At those shop plants so arranged as to make the principal buildings tributary to a single crane served thoroughfare, a portion of the storehouse platform is usually within the span of the crane to provide for handling and delivering heavy material.

At Silvis, C., R. I. & P. Ry., a large platform 400 feet long and 134 feet wide, for the storage of heavy material, is served by a traveling crane of 5 tons' capacity, having a span of 80 feet. A delivery track along one side of the platform is within the scope of this crane.

At the Chicago & Northwestern Railway shops at Chicago and at the Burnside shops of the Illinois Central Railroad, traveling cranes have been installed in the storage yards, to facilitate the movement of material and the loading and unloading of cars.

At Collinwood, L. S. & M. S. Ry., a large area which occupies a space between two rows of the principal buildings is soon to be served by an outdoor traveling crane and will be used as a storage yard for heavy material.

While the idea of handling storehouse material by a crane in the yard is not new, such a device facilitates the movement of material to a large extent and provides a feature of economy especially in handling very heavy material kept in stock, such as cylinders, driving wheel centers, tires, frogs, boiler fronts, boiler sheets, pilots, etc.

An interesting instance in this connection is the crane designed and constructed to meet local requirements at the Chicago shops of the Chicago & Northwestern Railway. This crane has a span of 45 feet and the runway supported on wooden frames covers a distance of 475 feet. The crane has a capacity of 5 tons and the motors are driven by current taken from the shop power house. As an instance of the economy represented by the installation of this crane, it is interesting to observe that, with the assistance of the crane, two men now do the work formerly requiring ten men.

SCRAP.

With very little exception all scrap that accumulates on a railway system has a market value and it is therefore of the utmost importance that scrap material should be taken care of and delivered to the proper department with as little loss of time as possible. It is now generally conceded that scrap should be handled by the store department and on most railways this practice is followed.

At the 1905 convention of the Railway Storekeepers' Association, an excellent paper on the subject of scrap, scrap handling and credit, was presented by Mr. W. G.

Tubby, general storekeeper of the Great Northern Railway. This paper described a system of handling scrap by which such satisfactory results have been obtained that it is believed representative of up to date practice and the paper is reproduced in part as follows:

"On the Great Northern system all scrap is approximately turned over to the store department as soon as made, or as soon after as convenient, and the proper accounts credited with the value of same; so that all scrap on the entire system is cleaned up each month. Maintenance of way scrap that has accumulated at the section tool houses during the month is picked up by the supply cars.

"All scrap brass is delivered to the storehouse by the mechanical department, with credit ticket made out as fast as it accumulates, and credited to the proper account. On receipt of the scrap brass at the storehouse it is weighed, graded and put in the bins assigned for same, which bins are located in the storehouse under lock and key.

"The heavy scrap from the machine shop, and all from the blacksmith and boiler shops, is loaded on cars specially assigned for scrap service at the shops as it accumulates. Credit tickets are made out and turned over to the store department, who have the cars switched to the scrap bins to be unloaded, sorted and graded, and the scrap received is checked against the credit tickets turned in, so that all scrap is credited to the accounts for the month in which it belongs. In this way there is no scrap left scattered around the shops or grounds.

"By locating the west end of the scrap bins convenient to the door of the machine shop, all turnings and borings and all scrap that can be handled by push car or wheelbarrow is delivered by the mechanical department to the scrap bins with credit tickets daily, and only the large scrap, such as wheel centers, cylinders, etc, are loaded on scrap cars assigned for that purpose. But all scrap from the boiler and blacksmith shops is loaded on scrap cars and delivered to bins for sorting and grading. This is both a convenient and economical arrangement.

"At smaller shops all scrap is delivered to the store department daily and credit tickets to the proper accounts turned in on delivery. At locomotive roundhouses and car repairing yards the scrap is delivered to the storehouse bins with credit tickets at the time requisitions are made for new material, so that the man who delivers scrap to the storehouse sees it weighed and takes the new material back with him.

"In the case of car repairing yards being located too far from the storehouse to deliver the scrap as removed, it is allowed to accumulate until a certain date each month, when it is weighed and loaded on cars and turned over to the store department with credit tickets; but in all other cases all scrap is delivered to the storehouse at the time new material is drawn. Scrap journal bearings, however, are delivered at the storehouse at the time new journal bearings are drawn, so that there is always a scrap bearing received when issuing a new one.

"All maintenance of way scrap, with the exception of rail, is delivered to the supply cars when making their monthly trips at the time the new supplies are delivered. The scrap which has accumulated on the sections during the month is assembled at the tool houses from time to time, and the section men educated to sort out the different kinds, so that on arrival of the supply cars the different kinds of scrap are quickly weighed and loaded and credit tickets made out in duplicate, and O. K.'d by the section foremen and supply car man, the original being sent to the division superintendent for his information to invoice against the store department for the amount and value of the scrap turned over to the supply cars, and the duplicate is sent to the storekeeper to check against the scrap received on the car when it arrives, and also to check against the superintendent's invoices when received. In this way there is no confusion or misunderstanding. The store department receives the scrap and accepts the superintendent's invoices for same.

"When the supply cars collect a load of scrap they bill the car to the storehouse from which they are operated, and another empty car is used. All track scrap, including frogs, crossings, split switches, switch stands, hand and push cars, tools, etc., in fact, all scrap, with the exception of rail, is cleaned up each month and loaded on the cars which accompany the supply cars delivering the monthly supplies. In this way all the scrap on the system is shipped to the stores each month with the exception of scrap rail, this being loaded by division superintendents as often as convenient.

"In order to get the best results in handling scrap, it is essential that all concerned be educated to the fact that the different parts must be separated, the usable from what is actually scrap, and the cast or malleable from steel, wrought, etc., as each kind of scrap has a different market value, and also that all scrap must be turned over to the store department as soon as possible and credited to the proper accounts. Also, the store department insisting on old tools and other material being turned in, so far as can be done, at the time new material is issued. By this method all scrap is in the hands of the store department, practically, as soon as it accumulates, when it is sorted, graded and the usable material separated and put into stock for further service, and the scrap sold at the option of the purchasing agent

"It has been explained how scrap is delivered to the store department, but the question of handling the scrap after being received, in order to produce the best results at the least possible expense, which includes sorting out second-hand usable material, and material that can be repaired at a cost that would warrant doing so, in preference to scrapping, is a very important one.

"In the first place, a thoroughly competent foreman who has a good knowledge of the different kinds of usable material and its use, and the grades of scrap, should be assigned in charge of the scrap bins, also steady and intelligent laborers assigned him; and these men should not be taken off the work so long as there is work to do, as they only become efficient by long experience. It is also advisable and economical to pay one or more of the old experienced men a few cents per day higher rate than the other laborers with whom they are working, in order that they may be relied upon to retain their positions and watch the other men and see that usable material is not being scrapped, or scrap not correctly graded, which latter is of great importance when loading on sales orders.

"To handle scrap economically a proper system of scrap bins should be provided, the floor of the bins being on a level with the deck of cars, and the bins of sufficient capacity to meet all requirements. Scrap bins which the Great Northern Railway use at their new Dale street shops are giving entire satisfaction, being convenient, economical and ample in every sense of the word. The bins are 600 feet long by 38 feet wide, which includes a platform on one side 8 feet wide on which is located a standard-gauge track for the operation of push cars which are used in moving the different kinds of scrap for delivery to the proper bins. On this platform, in front of the bins, are two track scales on which to weigh the scrap loaded on push cars, which is a convenient and economical arrangement. All cars containing scrap from shops or shipped in from different points on the line is unloaded on push cars on this platform for delivery to the bins after being weighed.

"On the opposite side there is no platform, but a track is located where cars are placed at the bins for loading scrap on sales orders. By having no platform on the sales side, there is no lost ground to travel over in loading scrap into the cars, as would be the case if scrap was loaded on the sorting side. The tracks on each side of the scrap bins lead together at the ends. At the east end they lead to the track scales, where all empty and loaded cars are weighed. This prevents delay while switching, as if switching is being made on the scale's side the men can be moved over to the sorting side and continue at work until the cars are placed for them to resume loading. Or, if the cars are on the sorting side being switched, the men can be used in loading, or moved over to the main storehouse, which is only a few feet distant, the scrap bins being located parallel to the main storehouse, and connections made at each end by swing bridges which can easily be turned by one man, and thereby kept at work at all times while switching is being done. The west end of the scrap bins is opposite to, and only a few feet distant from, the door of the machine shop, with turntable at end of incline track from platform, so that scrap can be loaded on push cars and run over to the incline, turned, weighed on the platform track scales, and delivered to the bins in which the scrap is to be placed.

"At each end of the scrap bins a number of bins have been roofed over, and in these bins are stored the different kinds of borings and turnings, No. 1 and No. 2 wrought, foundry coke, sand and ashes, scrap hose, rope and sacking, and other scrap which should be under cover; the balance of the bins are uncovered.

"In connection with the economical handling of scrap I would not recommend contract labor unloading, sorting and grading of scrap at a price per ton, for the reason that there is so much good second-hand, or material that can be replaced cheaply, which would be liable to be scrapped if paid for at a contract price, the principal thing the contractor would have in view being the tonnage; and I consider the best and most economical results can be obtained by having a thoroughly competent, conscientious foreman in charge of the scrap yard, who knows his business, so that no material but what is actually worthless would be scrapped

"The railway scrap pile furnishes an interesting and instructive object lesson, for there you find the remains of the material that has been purchased new and put into service by the different departments in the operation and maintenance of the road, for by studying the breakages, the weakness and defects of the material taken out of service are located, and if necessary a remedy is provided.

"The system of handling scrap on the Great Northern Railway and the results secured have been highly satisfactory, especially so from an economical standpoint, since the new scrap bins at the general stores, St. Paul, have been put into commission."

OIL HOUSE.

At a large or general railway shop plant the oil house is usually a small, fireproof building isolated from the other buildings. At small shop plants a section of the storehouse is frequently devoted to the storage and delivery of oil and waste.

LOCATION.

Where oil is handled through the storehouse the location of the oil handling department is naturally dependent upon the situation of the storehouse. That portion of the storehouse devoted to this department is selected to provide convenience in the delivery of oil to the roundhouse and the shop buildings.

The location of the isolated oil house is dependent upon several conditions. Its natural location is near the storehouse, and at the same time it should be in a situation convenient to the several shops operating machinery. Where a roundhouse is included in the shop plant, it is very essential that the oil house should be in close proximity to the roundhouse in view of the large amount of oil delivered to supply locomotives

The location of the oil houses at Burnside, I. C. R. R., and at Silvis, C., R. I. & P. Ry., repre-

sents a convenient method of disposing of this building. In each case the oil house is reached by the platform serving the storehouse, and while not directly between the storehouse and the roundhouse, it is located conveniently with regard to both of them, and is also accessible from the other buildings. At Elizabethport, C. R. R. of N. J., the roundhouse is not near the storehouse and there are several buildings between them. At this point the oil house is isolated and is near the roundhouse. At the same time it is easy of access from the locomotive shop.

BUILDING.

The oil house usually consists of one floor and a basement and the floor is commonly four feet above grade, on the level of an ordinary car floor. The walls are usually of brick supported on concrete foundations and the roof is supported by steel roof trusses or by a wooden framework of slow-burning mill construction. The basement is arranged to contain oil storage tanks, and a convenient method of arranging the main floor is to divide it into three sections, a shipping room, a barrel room and a waste room. The rooms are separated by fire walls having fireproof sliding doors. The basement and main floor are connected by a steel stairway.

The oil house is commonly heated by steam pipes and those pipes in the basement are carried along the wall or between the tanks. Steam pipes placed in the tanks are unsatisfactory because of their liability to leak and their inaccessibilty for repairs.

DELIVERY.

The most convenient method of delivery to the storage tanks is by gravity from a tank car placed on an adjacent track or by gravity from barrels placed immediately over the storage tanks. While these methods have not been followed always they represent the most common practice.

Delivery from the tanks is generally made at some one convenient point. The faucets through which delivery is made are assembled and are connected by pipe lines with the several tanks.

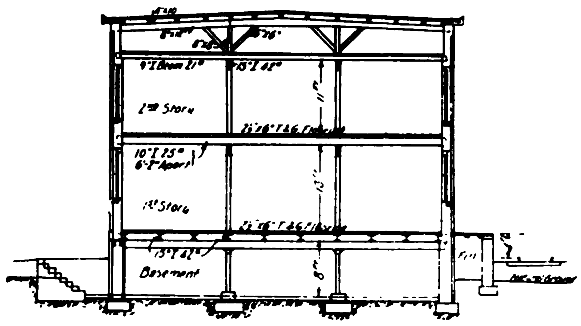
Oil is raised to the point of delivery either by compressed air or by pumps, and in some cases both air and pumps are installed. Water entrained in the air pipes is apt to become mixed with the oil, and due to its deteriorating effect upon illuminating oils, these oils are usually delivered by pumps.

In order that the storage tanks shall not be kept under air pressure, oil is led by gravity into a small reservoir which is properly equipped with check valves and air connections. The oil is then delivered by compressed air from the reservoirs through the pipe lines to the faucets, air control valves being situated conveniently near the faucets.

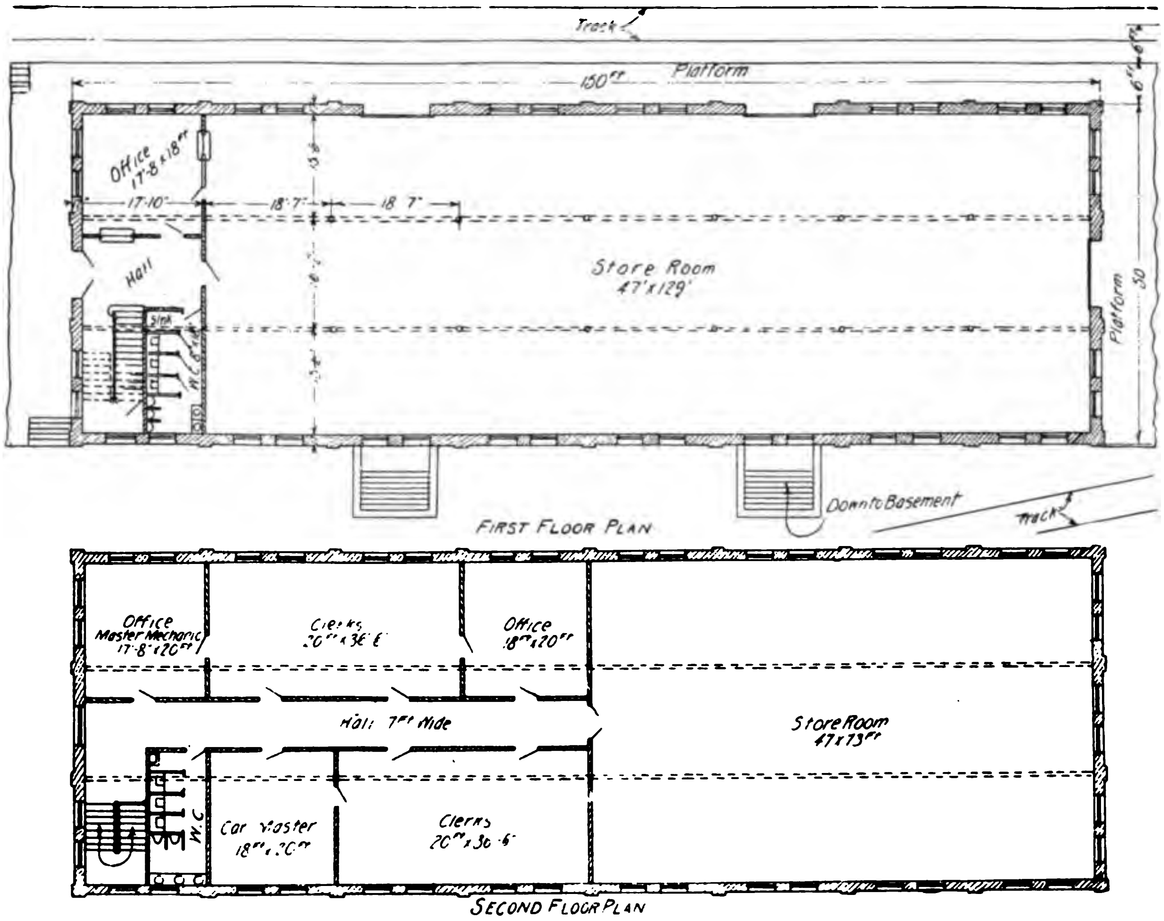
An ingenious system of oil delivery has been developed whereby oil is delivered from the storage tanks by pumps which may be set to measure the desired amount and deliver accurately only the amount required. This system not only represents a saving in handling oils but further serves to provide an accurate measure of the oil which has been removed, by which may be determined the amount of oil remaining.

A further convenience of this system is that the storage tanks are not necessarily in the same building as the delivery pumps. For instance, at the Collinwood roundhouse of the L. S. & M. S. Railway, as well as at some other points, the storage tanks are in the basement of an isolated oil house, while the pumps controlling the delivery of oil are in the small store room connected with the roundhouse. The pumps occupy a small space so that they do not crowd the store room and they do not present an unsightly appearance.

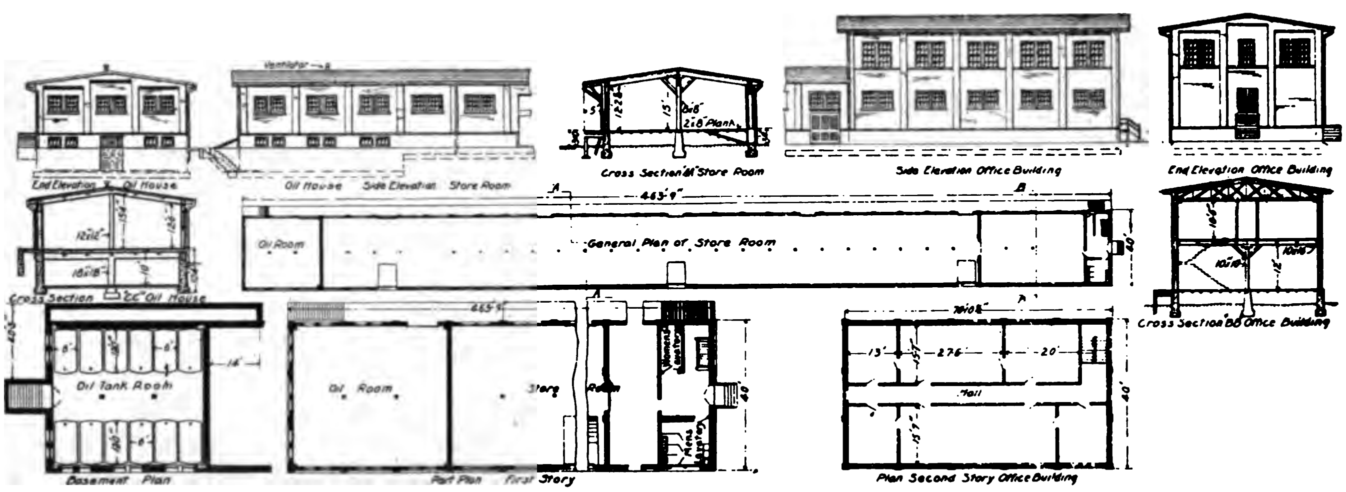
The engravings presented with this chapter illustrate designs and dimensions of a number of representative oil houses as well as several systems of storing and delivering oil.



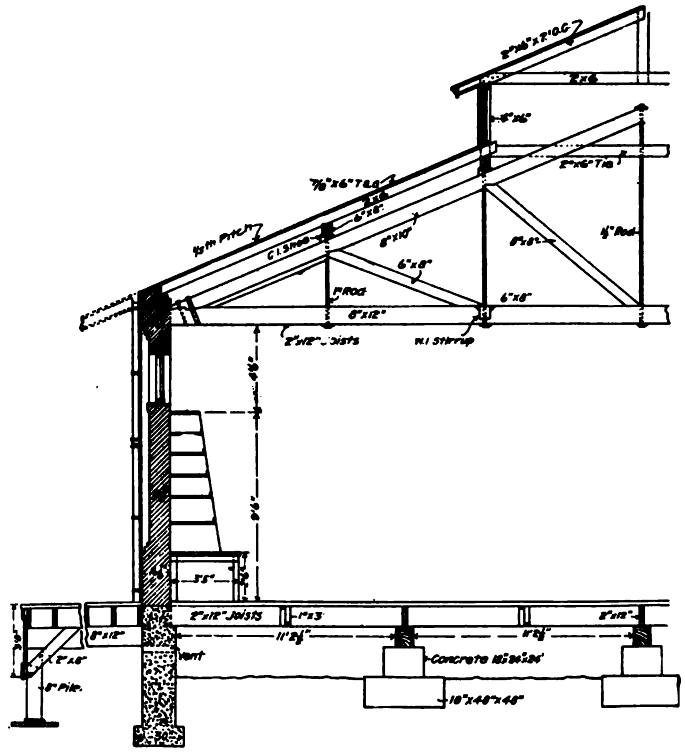
CROSS SECTION THROUGH OFFICE BUILDING AND GENERAL STOREHOUSE AT BARING CROSS, ARK.
ST. L. I. M. & S. RY.



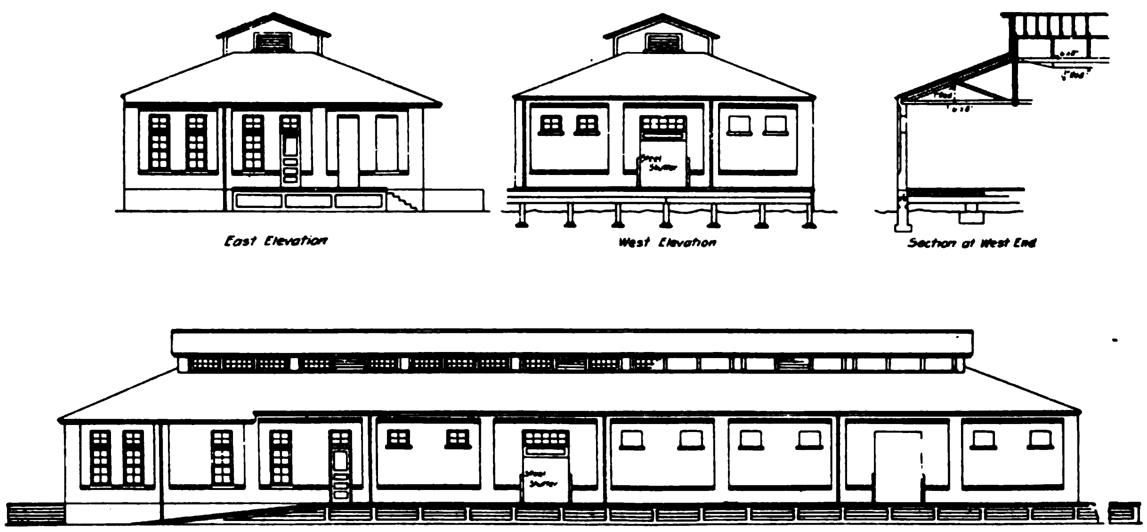
PLAN OF OFFICE BUILDING AND STOREHOUSE AT BARING CROSS, ARK., ST. L. I. M. & S. RY.



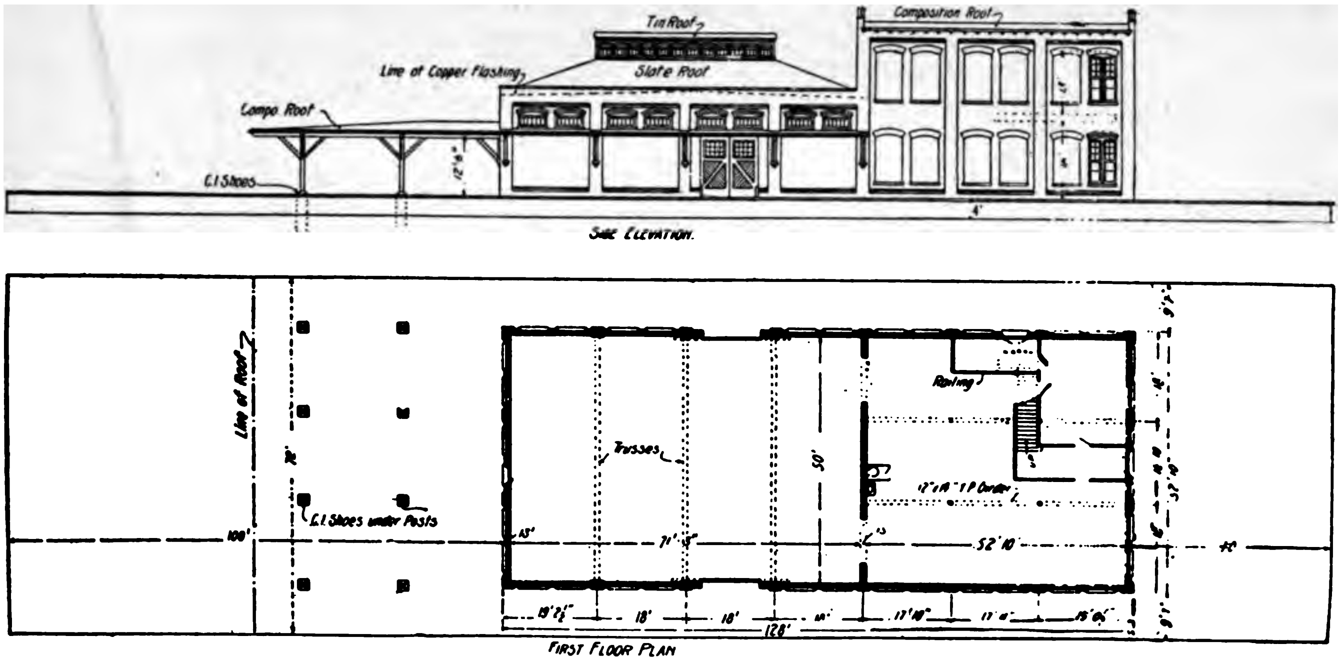
PLANS AND ELEVATION OF STOREHOUSE AND OFFICE BUILDING AT EAST DECATUR, ILL., WABASH RY.



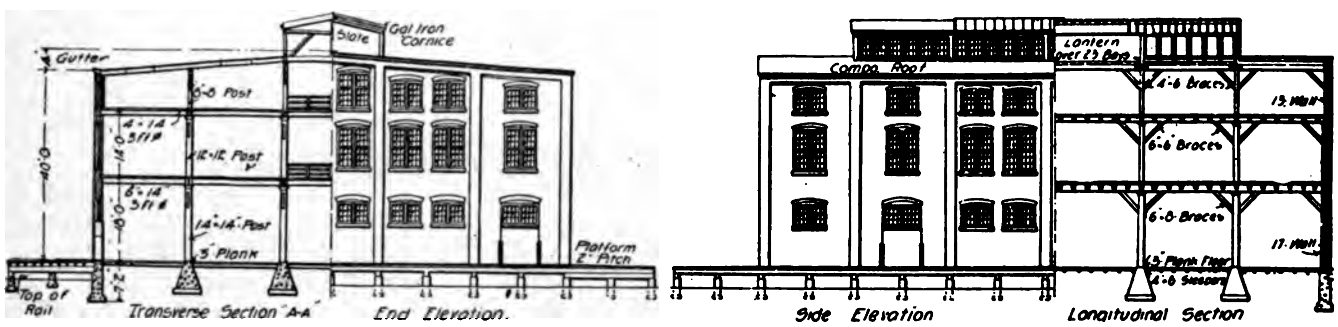
PARTIAL SECTION OF STOREHOUSE AT LA JUNTA, COLO., A. T. & S. F. RY.



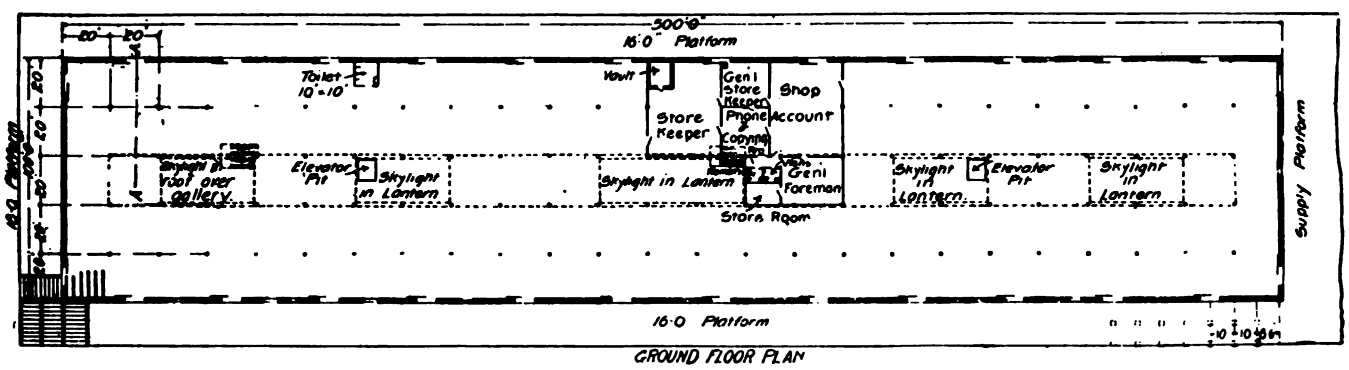
ELEVATIONS AND PARTIAL SECTION OF STOREHOUSE AT LA JUNTA, COLO., A. T. & S. F. RY.



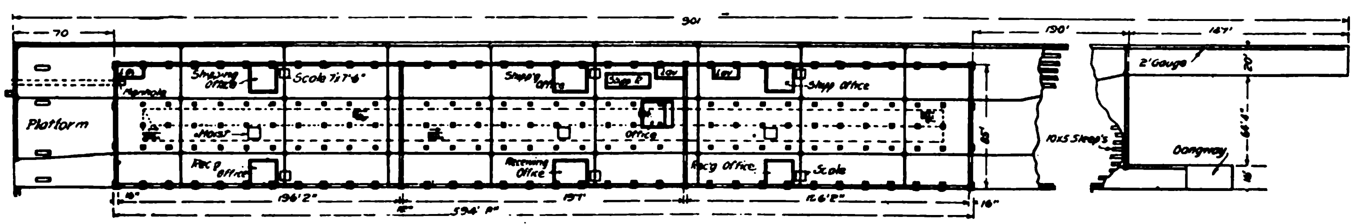
PLAN AND ELEVATION OF STOREHOUSE AND OFFICE BUILDING AT EAST ST. LOUIS, ILL., T. R. R. ASSOCIATION OF ST. LOUIS.



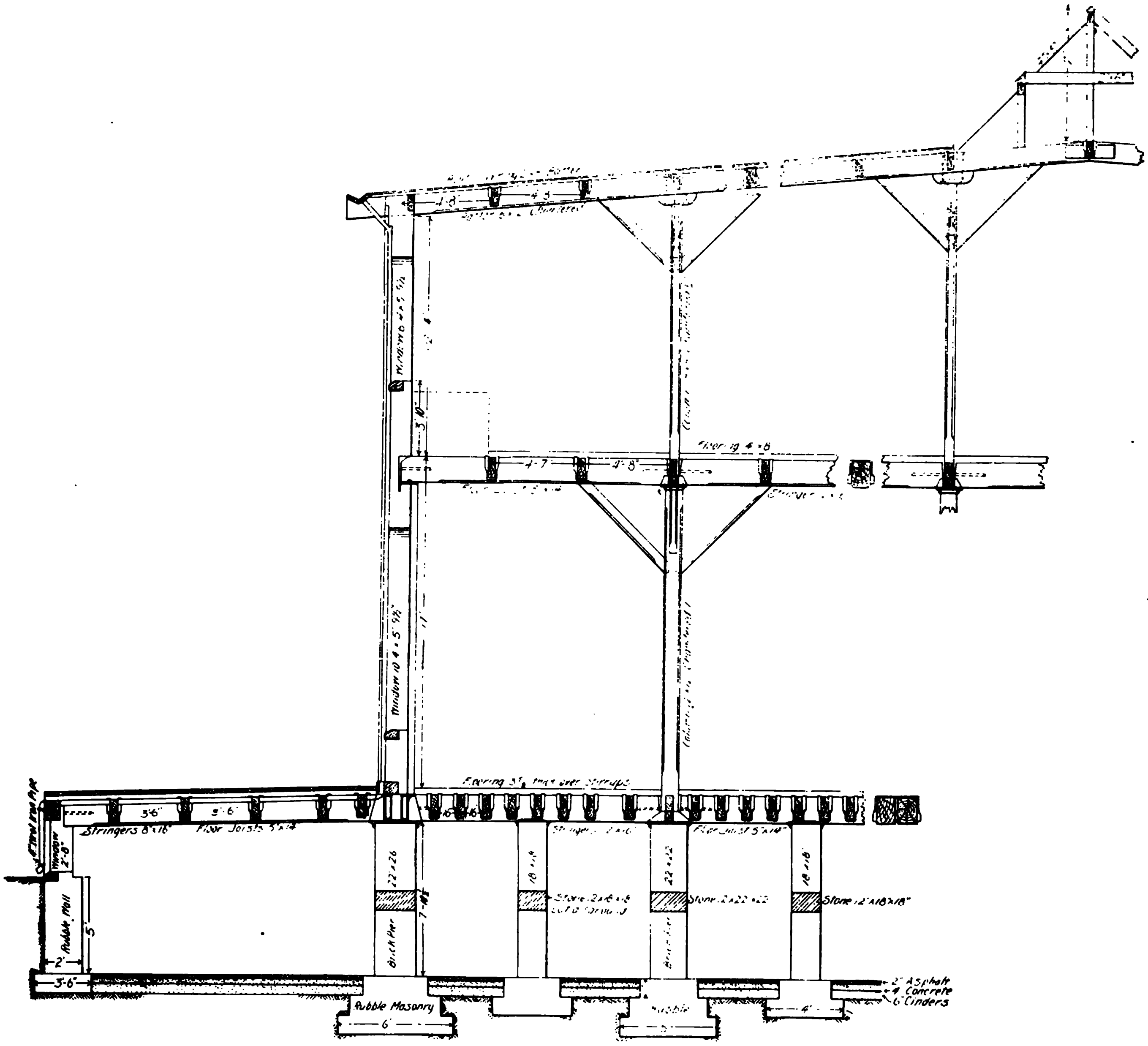
SECTION AND ELEVATION OF STOREHOUSE AT SILVIS, ILL., C. R. I. & P. RY.



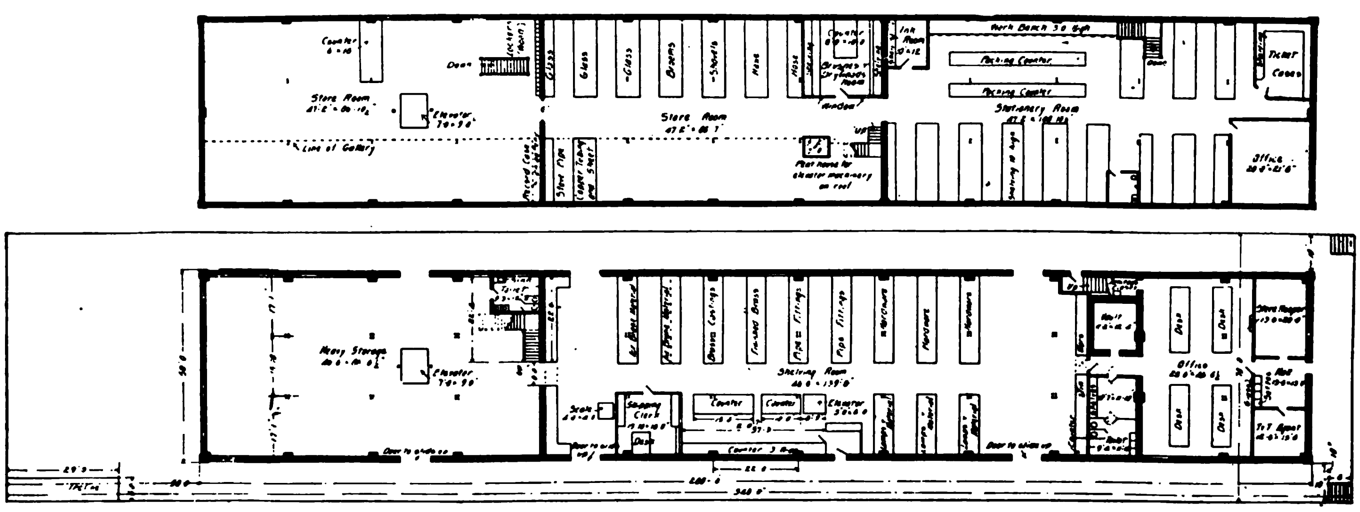
PLAN OF STOREHOUSE AT SILVIS, ILL., C. R. I. & P. RY.



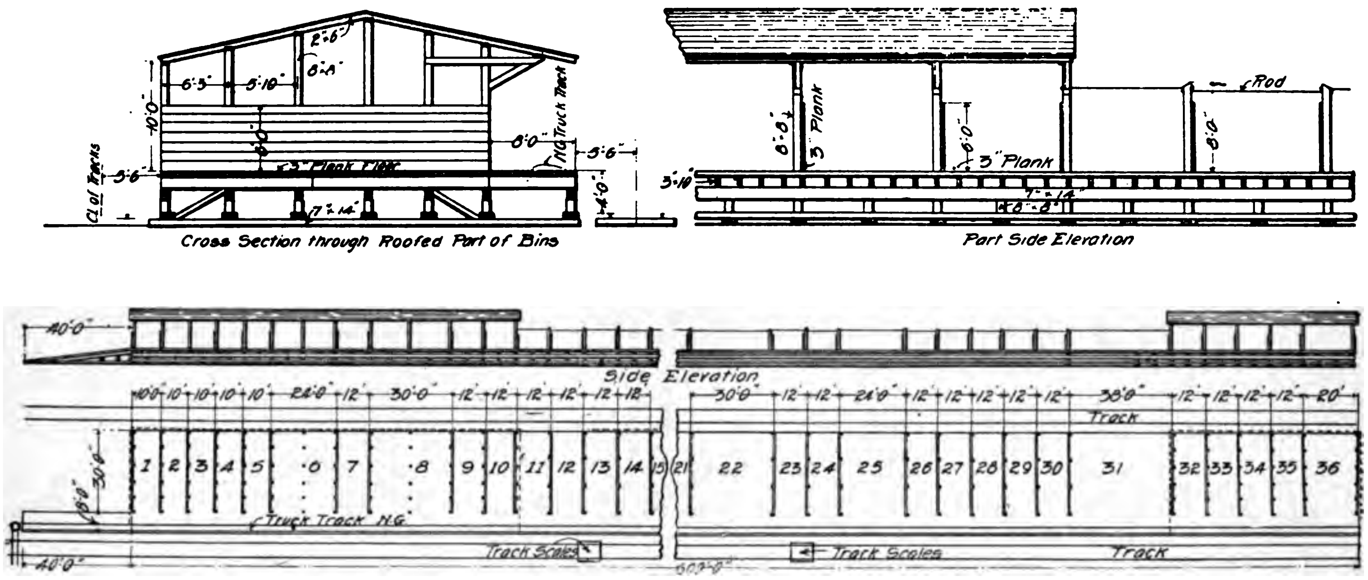
PLAN OF STOREHOUSE AT ANGUS, C. P. RY.



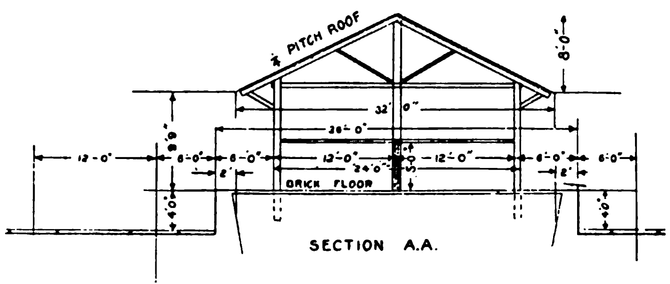
PARTIAL CROSS SECTION OF GENERAL STOREHOUSE AT BURNSIDE, ILL., I. C. R. R.



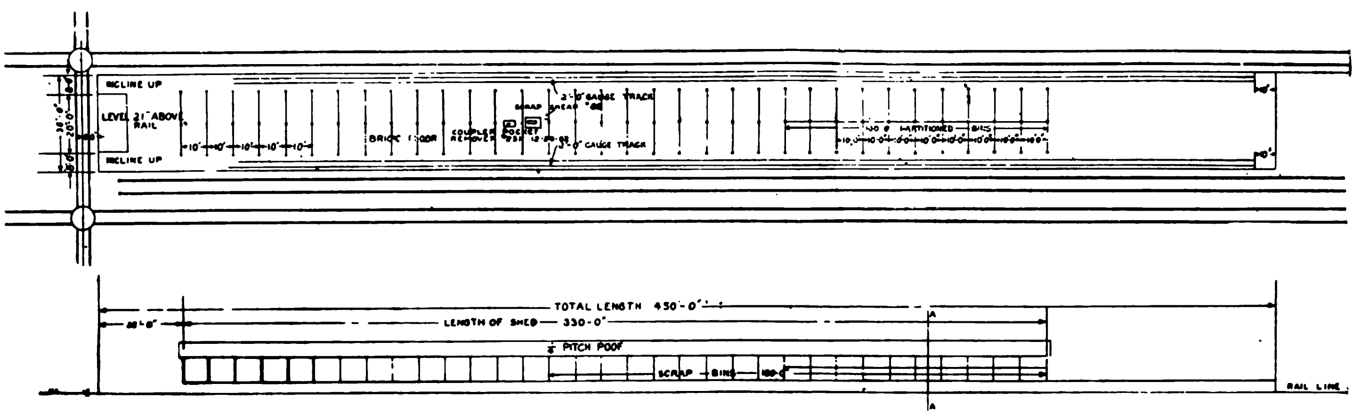
PLAN OF STOREHOUSE AND STATIONERY DEPARTMENT AT OMAHA, NEB., U. P. RY.



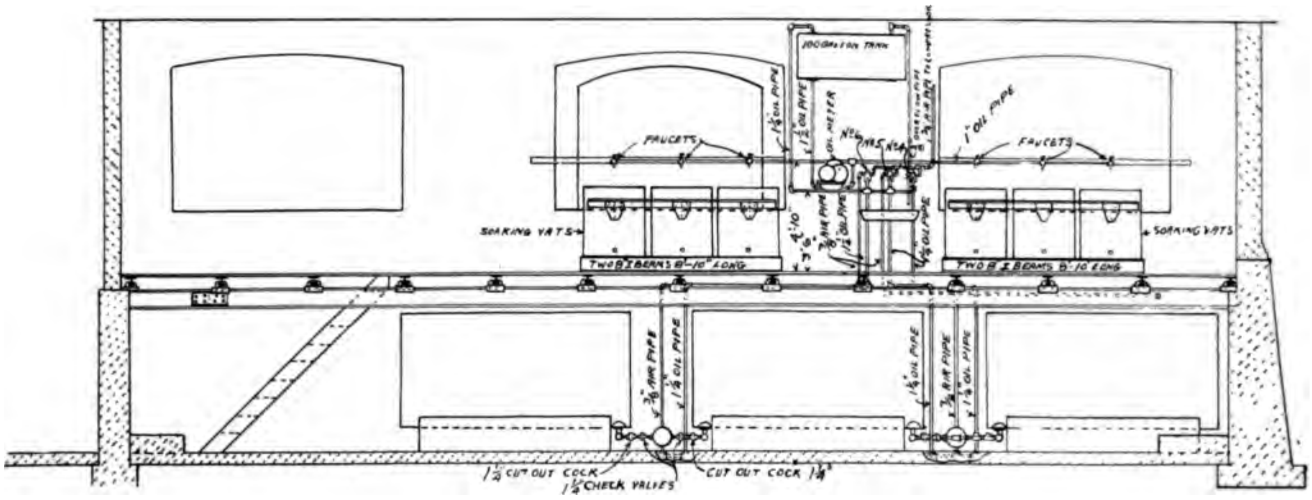
SCRAP PLATFORM AT DALE ST., ST. PAUL SHOPS, OF THE GREAT NORTHERN RY.



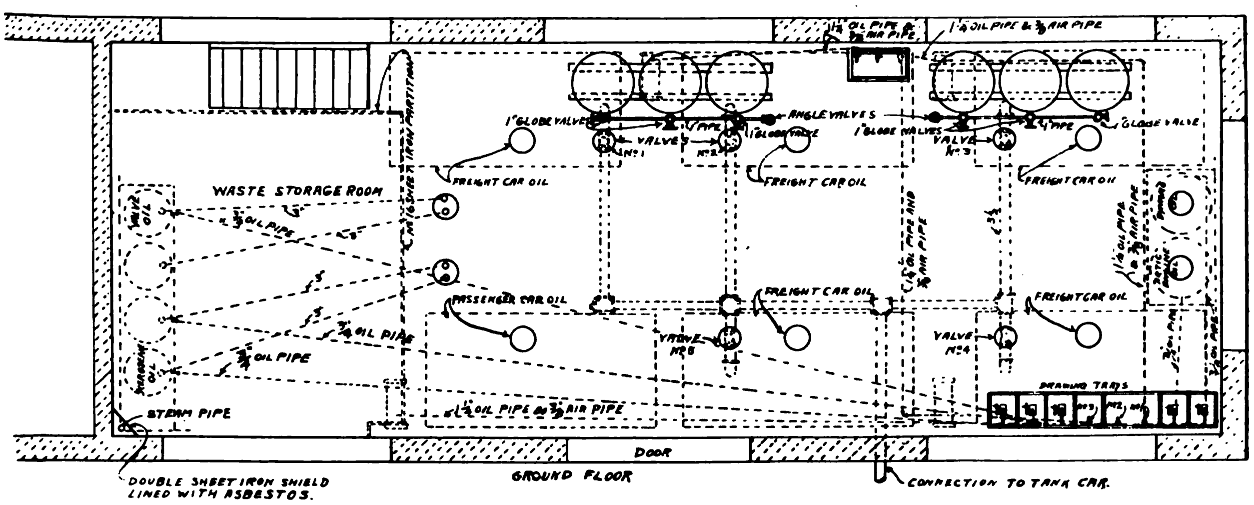
SECTION OF SCRAP PLATFORM AT COLLINWOOD SHOPS, OF L. S. & M. S. RY.



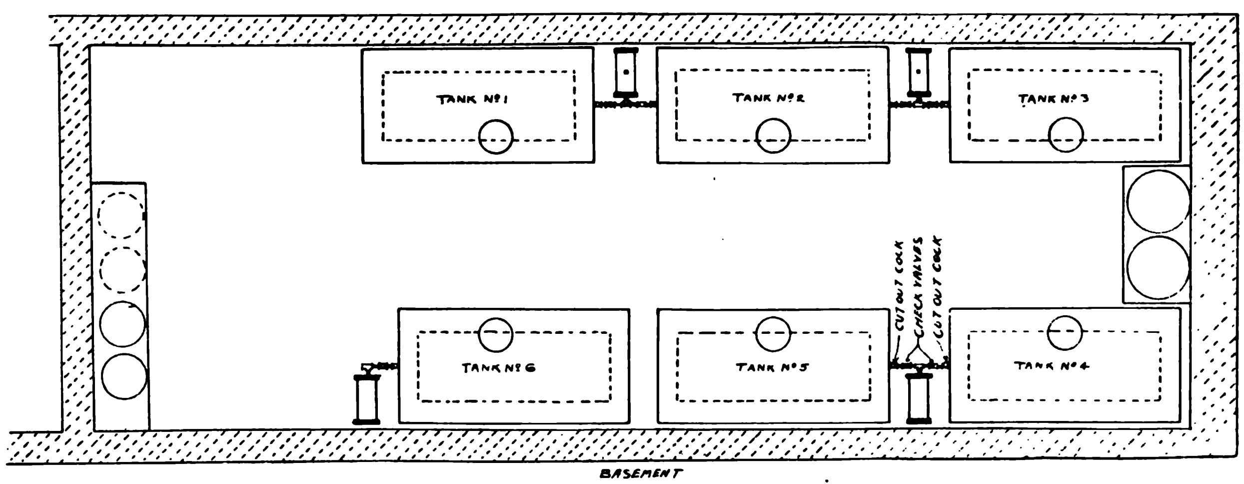
SCRAP PLATFORM AT COLLINWOOD SHOPS, L. S. & M. S. RY.



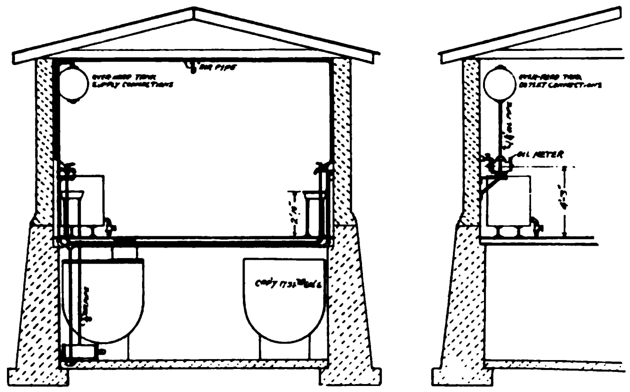
LONGITUDINAL SECTION OF OIL HOUSE AT SCRANTON CAR SHOPS, D. L. & W. R. R.



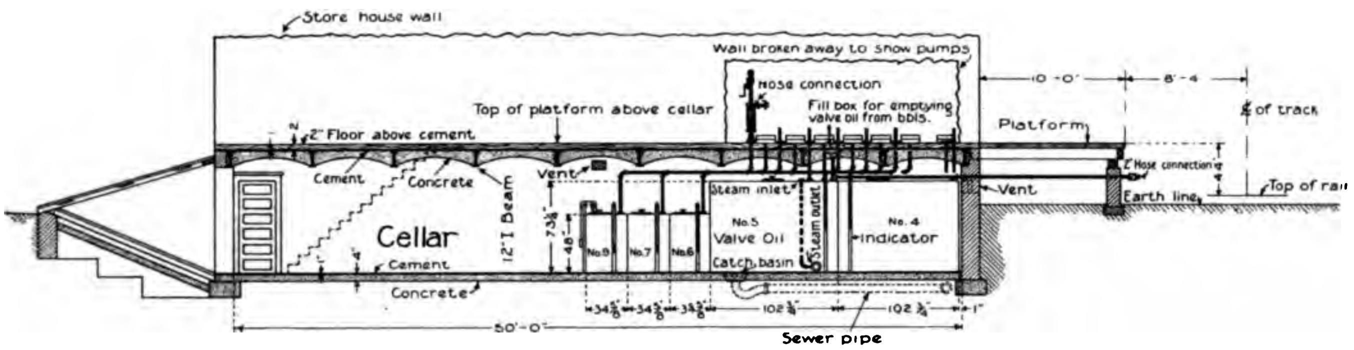
PLAN OF GROUND FLOOR OF OIL HOUSE AT SCRANTON CAR SHOPS, D. L. & W. R. R.



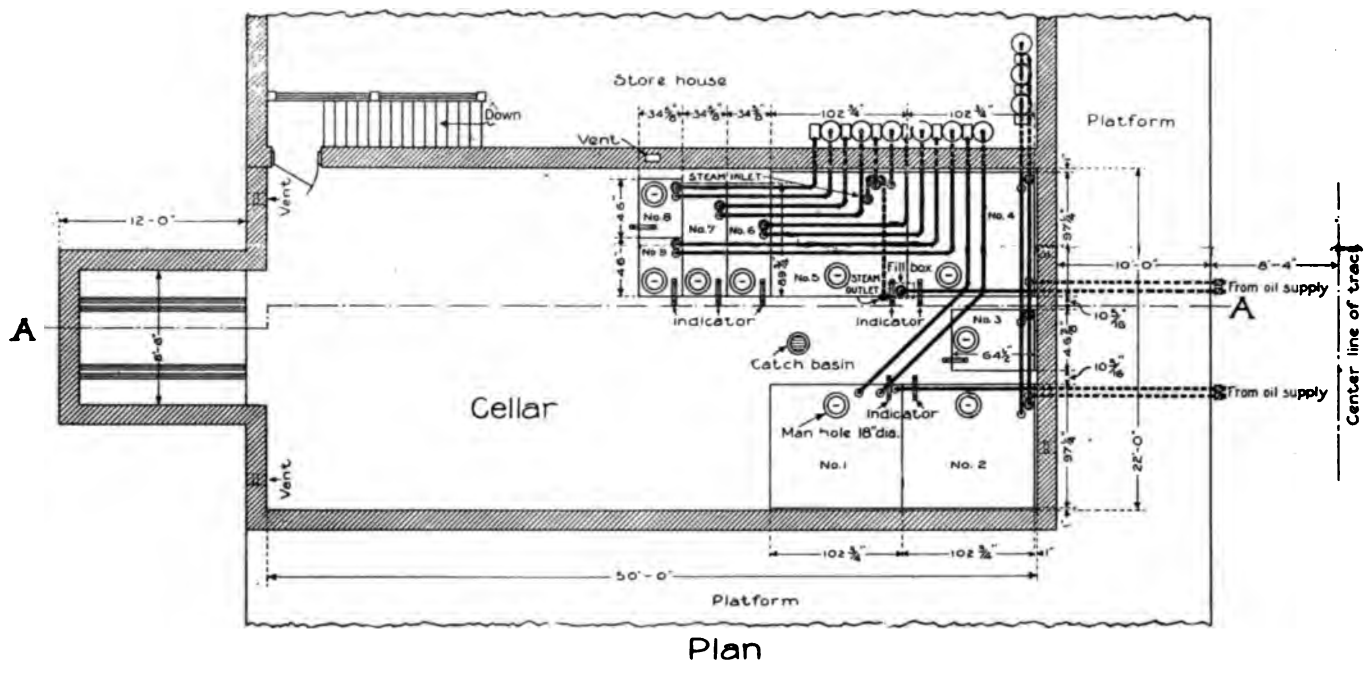
PLAN OF BASEMENT OF OIL HOUSE AT SCRANTON CAR SHOPS, D. L. & W. R. R.



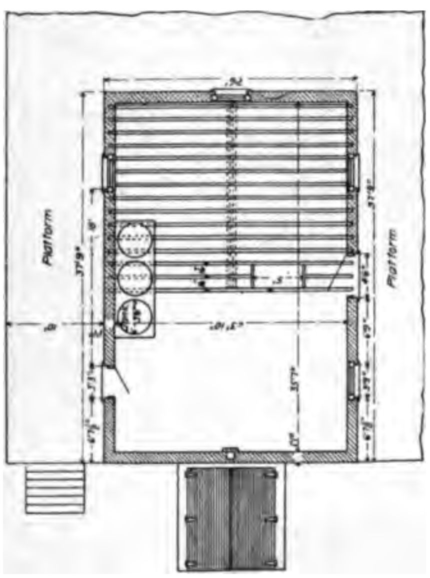
CROSS SECTION OF OIL HOUSE AT SCRANTON CAR SHOPS. D. L. & W. R. R.



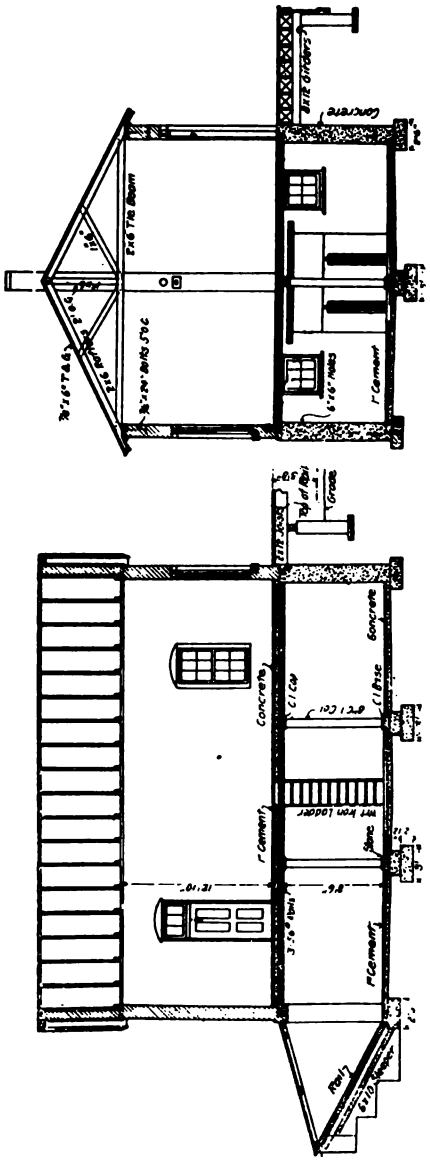
CROSS SECTION OF OIL DEPARTMENT OF STOREHOUSE AT SHOPTON, IA., A. T. & S. F. RY.



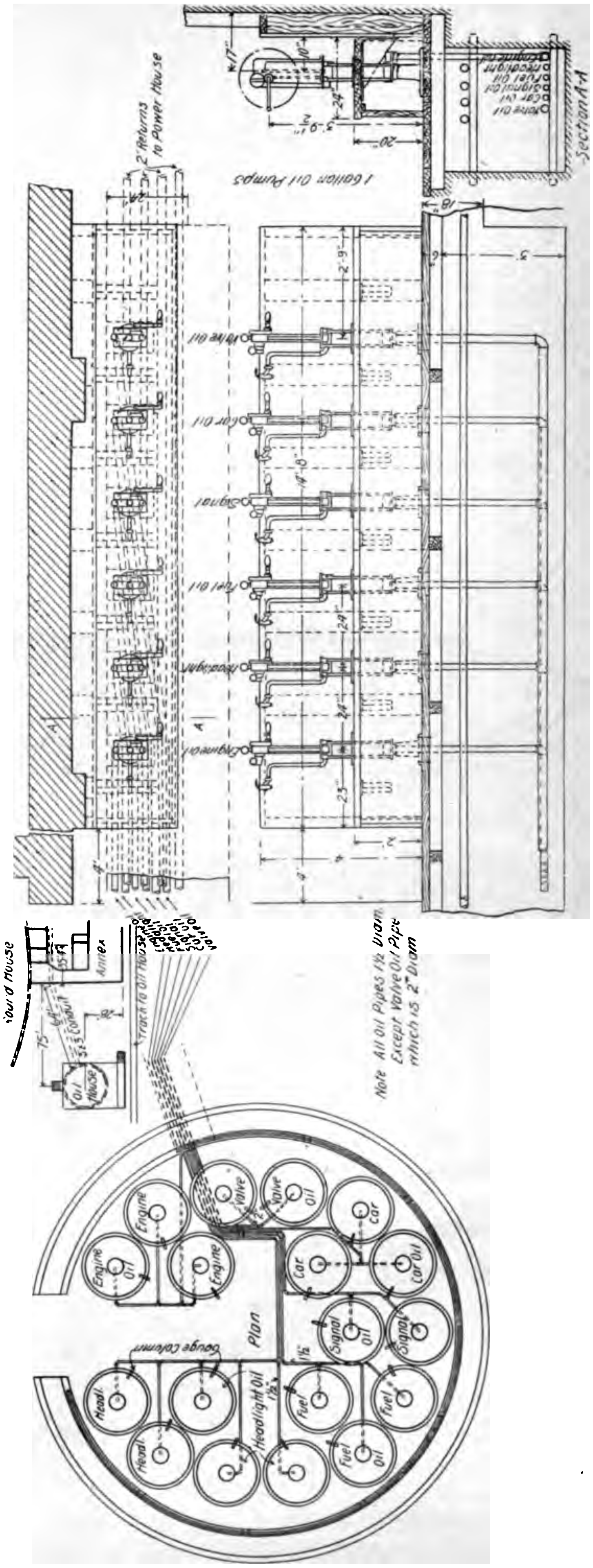
PLAN OF OIL DEPARTMENT OF STOREHOUSE AT SHOPTON, I A., A. T. & S. F. Ry.



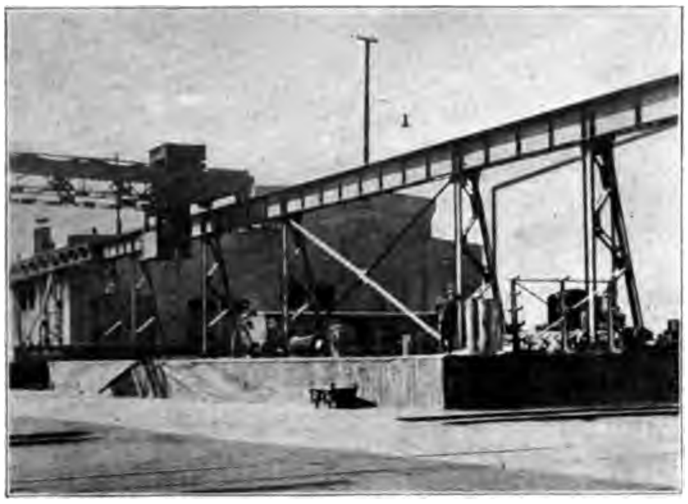
PLAN OF OIL HOUSE AT LA JUNTA, COL., A. T. & S. F. RY.



SECTIONS OF OIL HOUSE AT LA JUNTA, COL., A. T. & S. F. RY.



PLAN AND PARTIAL ELEVATION OF OIL SYSTEM AND CONNECTIONS AT COLLINWOOD ROUNDHOUSE, L. S. & M. S. RY.



PORTION OF STOREHOUSE PLATFORM SERVED BY MID-WAY CRANE, ANGUS SHOPS, C. P. RY.

CRANE SERVED THOROUGHFARE, OR MIDWAY, STANDARD GAUGE AND INDUSTRIAL TRACK AND CAR AT LEFT; PORTION OF STOREHOUSE PLATFORM AT RIGHT, ANGUS SHOPS, C. P. RY.

VIEW SHOWING TURNTABLE IN STOREHOUSE AT ANGUS SHOPS, C. P. RY.

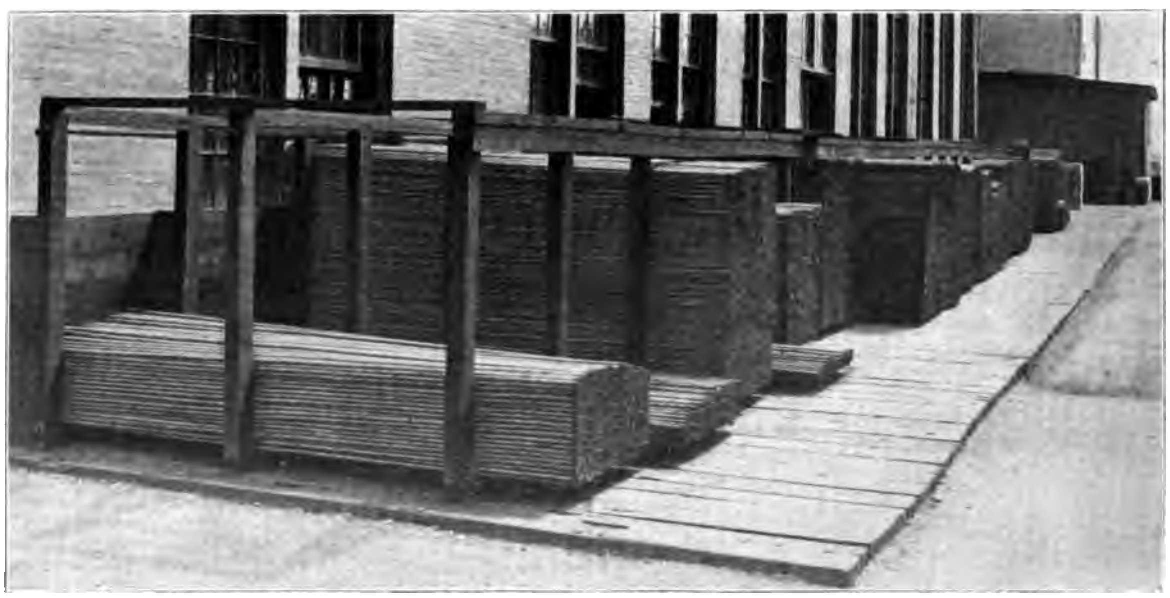
BRASS AND COPPER TUBE RACK IN STOREHOUSE, AT ANGUS SHOPS, C. P. RY.

BRASS ROOM IN STOREHOUSE AT ANGUS SHOPS, C. P. RY.

INTERIOR OF IRON HOUSE AT ANGUS, C. P. RY.

IRON SHED ADJACENT TO BLACKSMITH SHOP AT ANGUS, C. P. RY.

SYSTEM OF STORING BOLTS TEMPORARILY IN FREIGHT CAR ERECTING SHOP AT ANGUS, C. P. RY.



RACKS FOR STORING CAR BODY BRACE RODS AT ANGUS, C. P. RY.

CLASSIFIED BINS FOR STORING CAR CASTINGS ADJACENT TO FREIGHT CAR ERECTING SHOP AT ANGUS, C. P. RY.

METHOD OF TRANSFERRING CASTINGS ON STANDARD GAUGE INDUSTRIAL CARS AT ANGUS, C. P. RY.

CAR WHEEL STORAGE YARD BETWEEN WHEEL FOUNDRY AND TRUCK SHOP AT ANGUS, C. P. RY.

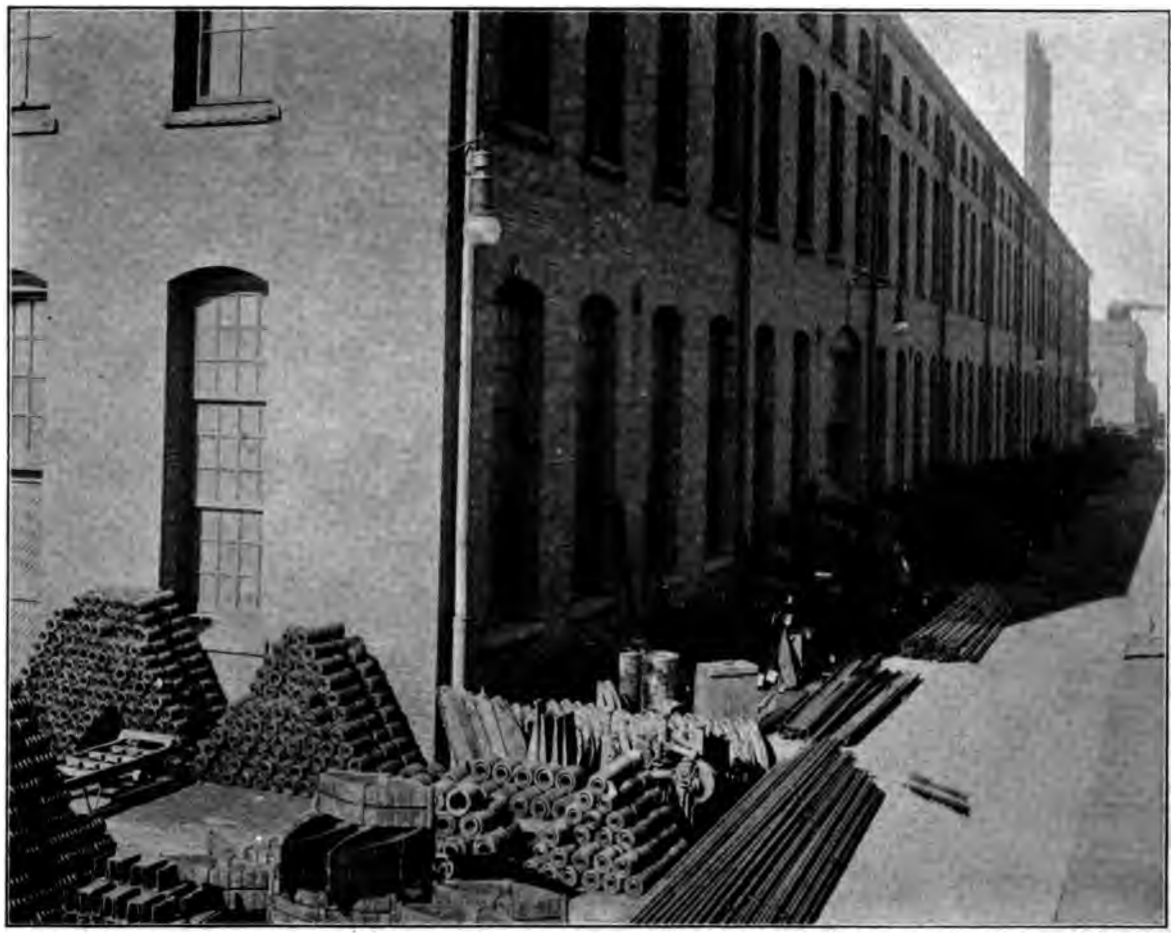
LUMBER YARD AT ANGUS, C. P. RY.

SCRAP PLATFORM AT ANGUS, C. P. RY.

UNLOADING BOLSTERS IN STORAGE YARD ADJACENT TO TRUCK SHOP AT ANGUS, C. P. RY.

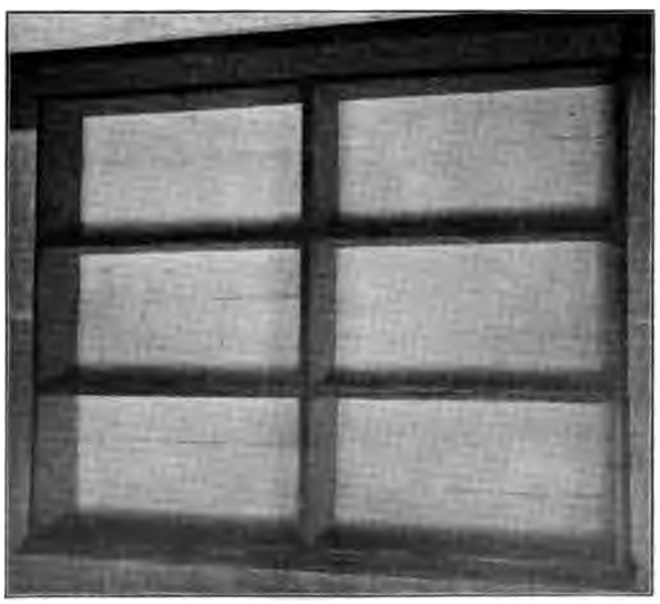
Railway Store Keepers' Association.

IRON STORAGE YARD AT ANGUS, C. P. RY.



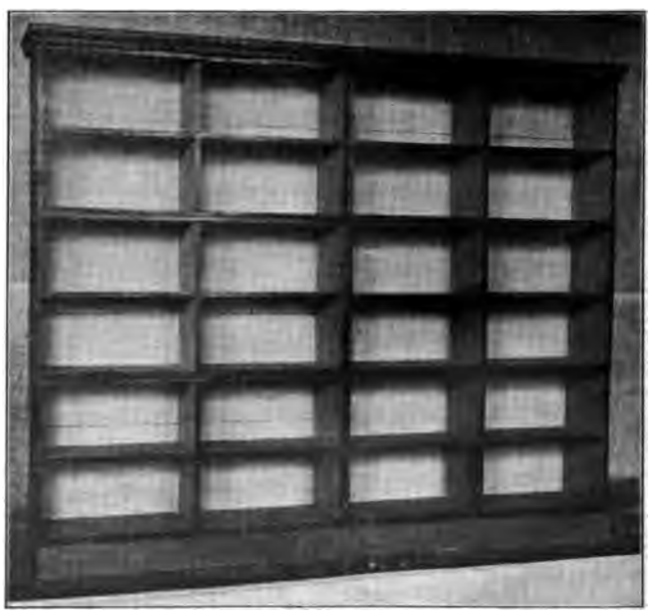
Railway Store Keepers' Association.

EXTERIOR VIEW OF GENERAL STOREHOUSE AT COLLINWOOD, OHIO, L. S. & M. S. RY.



Railway Store Keepers' Association.

SIX UNITS OF SECTIONAL, INTERCHANGEABLE SHELVES.



Railway Store Keepers' Association.

SIX UNITS OF SECTIONAL, INTERCHANGEABLE SHELVES, EACH UNIT DIVIDED INTO FOUR PARTS.

Railway Store Keepers' Association.

METHOD OF STORING MATERIAL ON FIRST FLOOR OF GENERAL STOREHOUSE AT COLLINWOOD, O., L. S. & M. S. RY.

Railway Store Keepers' Association.

METHOD OF SUB-DIVIDING UNITS OF SECTIONAL, INTERCHANGEABLE SHELVES.

Railway Store Keepers' Association.

METHOD OF SUB-DIVIDING UNITS OF SECTIONAL, INTERCHANGEABLE SHELVES.

WAGONS FOR TRANSPORTING BOLTS IN BULK AT COLLIN-
WOOD SHOPS., L. S. & M. S. RY.

Railway Store Keepers' Association.

RETAIL ROOM IN GENERAL STOREHOUSE AT COLLINWOOD, O., L. S. & M. S. RY.

PAINT STOCK ROOM AT ANGUS, C. P. RY.

Railway Store Keepers' Association.

ARRANGEMENT OF STORAGE SHELVES IN GENERAL STOREHOUSE AT COLLINWOOD, O., L. S. & M. S. RY.

Railway Store Keepers' Association.

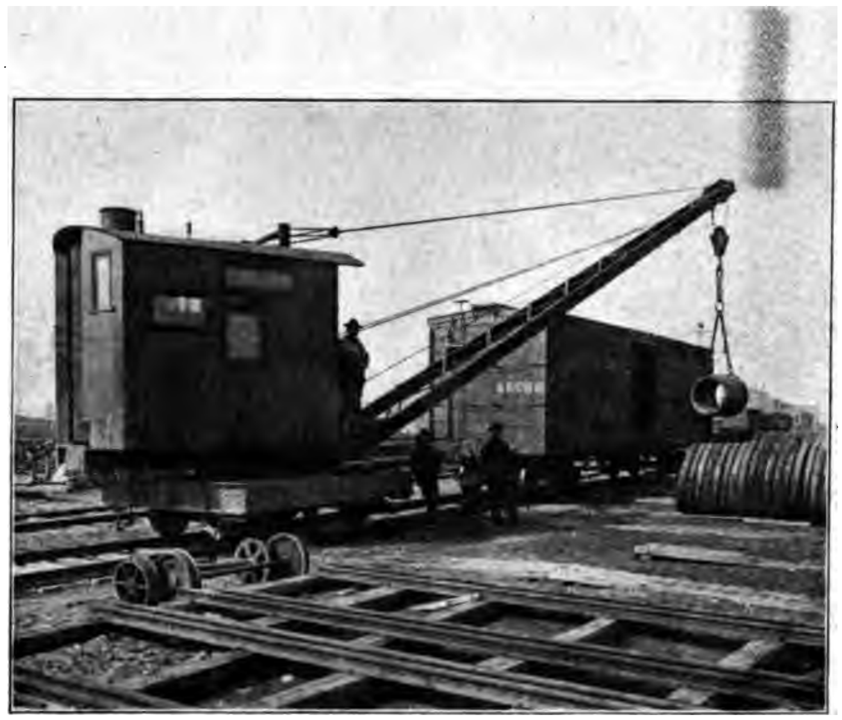
CASTING PLATFORM OF GENERAL STOREHOUSE AT COLLINWOOD, O., L. S. & M. S. RY.

Railway Store Keepers' Association.

MATERIAL YARD OF COLLINWOOD SHOPS. L. S. & M. S. RY.

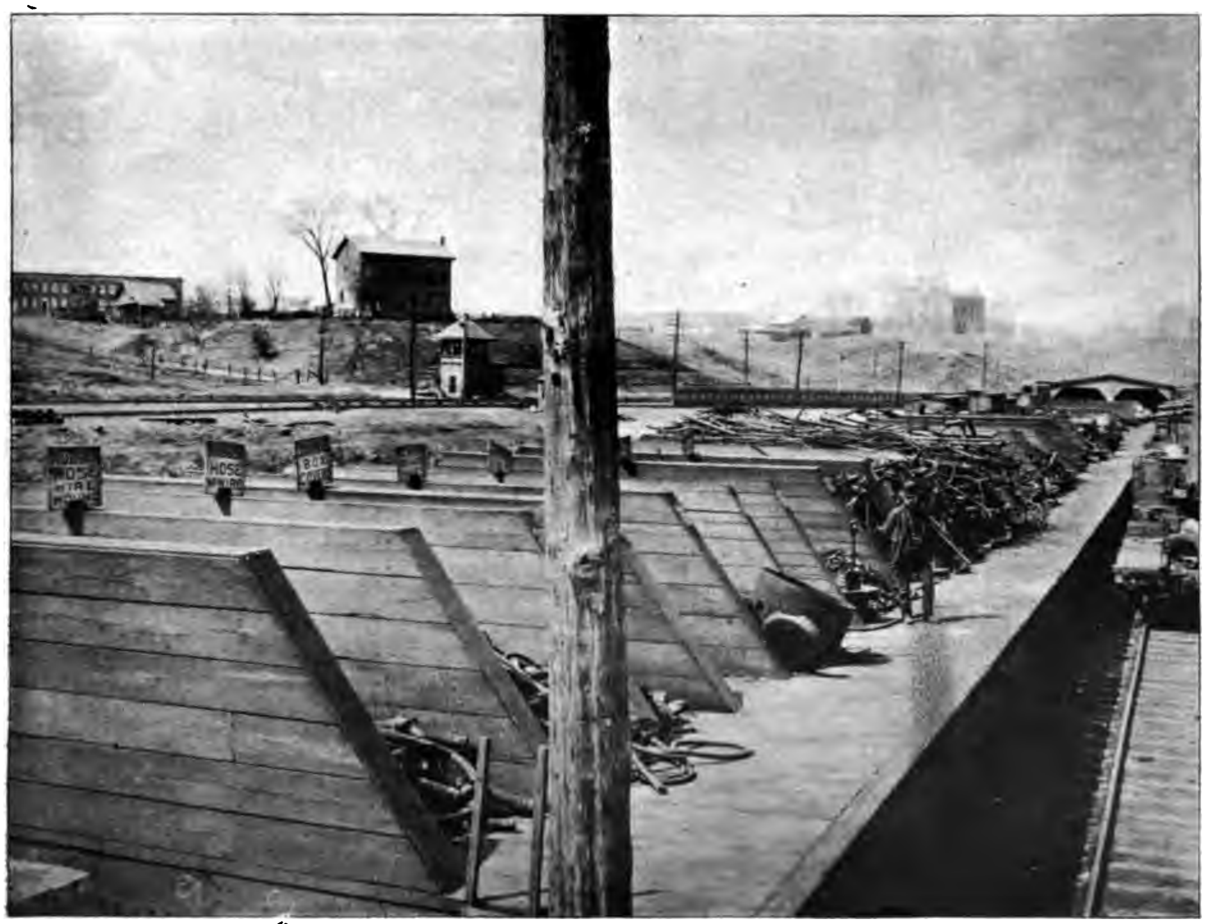
Railway Store Keepers' Association.
METHOD OF STORING MATERIAL AND SUPPLIES FOR LOCOMOTIVES IN GENERAL STOREHOUSE AT WEST ALBANY, N. Y., N. Y. C. & H. R. R. R.

Railway Store Keepers' Association.
CASTING PLATFORM OF GENERAL STOREHOUSE AT WEST ALBANY, N. Y., N. Y. C. & H. R. R. R.



Railway Store Keepers' Association.

CRANE USED IN STORAGE YARD AT ANGUS SHOPS, C. P. RY.



Railway Store Keepers' Association.

SCRAP PLATFORM AT WEST ALBANY SHOPS, N. Y. C. & H. R. R. R.

Railway Shop Up To Date

Chapter XI.

ROUNDHOUSE

THE roundhouse is a repair shop for the maintenance of locomotives in service. As such its efficiency depends upon the facility, with which locomotives may be received, turned, repaired and dispatched with minimum detention. A number of variable conditions affect the movements of locomotives at a terminal and for this reason a consideration of the roundhouse should include the general layout of the auxiliaries in the yard tributary to the roundhouse.

Roundhouses and engine terminal yards now in service on American railways represent many different degrees of development. It is a matter of very common knowledge that as a general thing engine house and terminal facilities have not kept pace with locomotive development and growth. At the same time, however, a number of terminal plants have been placed in commission within recent years which include roundhouses of excellent design, containing the best and most complete equipment and yard facilities arranged to move locomotives with quickness and precision.

The variable conditions affecting the arrangement of locomotive terminals and the difference of opinion among officers and designers, have produced types of roundhouse buildings and arrangements of terminal yards, that are very unlike in point of detail. In the main, the different designs and arrangements follow certain general principles; but beyond these, individual ideas have been followed to such an extent that it is impractical to attempt to outline a precedent according to which roundhouses have been designed and terminal yards have been arranged. At the end of this chapter a number of plans are presented which have been selected as representative of existing practice. Ideas of detail may be gathered to better advantage by referring to the individual drawings rather than by following extensive descriptive matter, and for this reason the text of this chapter is devoted principally to general features representative of practices which have been used successfully.

LAYOUT.

Locomotive terminals are either in connection with main or division shops, or constitute isolated plants in close proximity to a large terminal yard or passenger station. Where the roundhouse forms a part of a shop plant, its location is naturally as near as possible to the point at which locomotives are needed for road work. The presence of a roundhouse at a shop plant frequently influences the entire arrangement of the shop buildings and equipment. The layout of the shops is sometimes restricted by locating some of the buildings to serve the interests of the roundhouse, instead of arranging them in locations which advance the most economical and productive movement of material.

The roundhouse is commonly in close proximity to the locomotive shop where the delivery of wheels and other parts requiring machine work will be over the shortest route. It is also essential to provide easy access from the boiler and blacksmith shops.

In recent years several main shops have been built from which the roundhouse has been excluded. In some of these instances the roundhouse is near the shop plant, but is in no way a component part of it. Where this condition prevails a small shop plant is built in connection with the roundhouse to supply its immediate needs and the main shop is not called on to do roundhouse work, except on driving wheels or on emergency repairs which are too large for the roundhouse shop equipment. At some isolated roundhouses driving wheel lathes are included in the machine tool equipment.

With the development of freight terminal yards a number of isolated roundhouses have been built in close proximity to the yards to provide improved engine handling facilities near the points where the engines are required for service, thereby reducing the delay which frequently occurs between engine house and train, a feature of no small moment where a large number of engines are turned in 24 hours. A practice now becoming more and more common is to locate a roundhouse, with its necessary locomotive terminal facilities, between two freight classification yards handling cars for opposite directions.

Several railway companies have developed standard roundhouse and other facilities to meet the requirements of their various terminals. Even these, however, are subject to variation to meet the local conditions. In many of the details and in the equipment for handling work the general design of the standard system may be adhered to.

It is not only very common for a roundhouse terminal to handle engines from several divisions, but a single terminal frequently cares for the engines of several different railroads running into the same center. Separate terminals are often provided for freight and passenger equipment, but it is very common practice to handle both at the same terminal.

There are many different arrangements for meeting these various conditions, but none of them are governed by any general rule. At Clinton, Iowa, the terminal is arranged to care for engines of two divisions and a separate house is provided for engines of each division.

The Elkhart terminal of the L. S. & M. S. Ry. cares for both passenger and freight engines of two divisions terminating at that point. A roundhouse of 34 stalls is provided for freight engines and one of 16 stalls for passenger engines. A similar provision is made for freight and passenger engines of the Baltimore & Ohio terminal at Baltimore. The Union Terminal in Washington, D. C., cares for the passenger equipment of five different roads. It is very necessary to provide for the rapid handling and dispatching of all locomotives of the several roads, and as a single roundhouse with one table would hardly be capable of handling the power without detention, even under most favorable conditions, two semi-circular houses, of 25 stalls each, are used, each house being served by an individual turntable. To meet the demands of the large passenger traffic centering at St. Louis during the exposition in that city, a large terminal was erected which included three square engine houses served by transfer tables. Engines are turned on a Y near the passenger station.

Where two houses serve the same terminal the most convenient location of the small auxiliary shops is between the two roundhouses to provide for the movement of material, supplies and equipment, over the shortest possible distances. This practice is not always adhered to, as the layout is often governed by conditions requiring relative locations of the houses which will not permit such an arrangement. Both houses are sometimes served by the same cinder pits. Frequently, however, individual pits are provided for each house. A single coaling station commonly provides for all locomotives at a terminal regardless of the number of houses.

At the most modern roundhouses the arrangement of service auxiliaries is devised to expedite the movement of locomotives as much as possible. This provides for the location of the coaling station, sand house, cinder pits, water plugs, etc., in such relation to each other and to the roundhouse, that incoming and outgoing engines will not interfere and that an engine requiring an unusually large amount of cinder pit work will not block others which should be run into the house without loss of time. Comparatively recent innovations are outside inspection pits and locomotive storage yards. The former provides for the inspection of an engine as soon as it reaches the terminal in order that necessary repairs may be anticipated and arranged for before an engine enters the house. By the use of the storage yard the roundhouse maintains its true function as a repair shop and not as a storage space, and engines requiring no repair work may be placed on the storage tracks as soon as their fires are cleaned and coal, water and sand have been taken.

COALING STATION.

Coaling stations are generally constructed of wood throughout. According to the requirements of the railroad they are made with small individual pockets or large storage pockets. The latter type are provided sometimes with automatic weighing devices, which have improved this type of chute. An example of the small-pocket type is the station erected by the Chicago Great Western Railway at Oelwein, Iowa. It consists of 280 feet of level trestle and 696 feet 6 inches of incline, giving a total length of 976 feet 6 inches. There are 14 pockets in all, seven on each side. The chute is designed to use hopper-bottom cars, which are pushed up by switch engines. The outside aprons are pressed steel and counterbalanced. The gates are of very heavy construction, so that when released they will fall and stop the flow of coal at any desired point.

Another plan is that which has been used considerably by the Chicago & Alton Railway. The coal, ashes and sand are all handled in the one plant. Water cranes are located so that water may also be taken at the same time, and all the outside work on the engines can be done at one time and at one place. One man can take care of such a plant as this. The details of the plant consist of large pockets capable of holding from 60 to 100 tons of coal, which are suspended on scales. Autographic records of the amount of coal delivered from these pockets are made for the attendant and the engineer. A large storage pocket is also provided. Two tracks are covered, one for the receipt of coal and the other for the use of the locomotives. The coal is received in the underground hopper from the cars and delivered to the delivering pockets or storage bin as may be desired. The same conveyor takes the ashes from the ash hopper to the ash storage bin, from which they are delivered to cars. The sand, after being dried out, is elevated to the dry sand bin, from which it is passed to the locomotive. Small gasoline engines of from 15 to 20 horse power are used with these plants.

SAND HOUSE.

For the drying of sand, small houses are often specially provided, but a tendency is noticeable in all recent construction to combine the sand apparatus with the coal chute, as in the Chicago & Alton stations. The general method of drying the sand is to use a stove of heavy cast-iron construction around which the sand is held by a suitable hopper. The wet or green sand is fed into this hopper, and the dry sand passes out of holes provided at the bottom. After drying, it is screened and is then ready for the storage bin. Steam driers are used to some extent; especially where some steady supply of exhaust steam is available. They usually consist of some sort of hopper through which a large number of pipes are passed, and so located that the sand cannot pass through without being thoroughly dried and roasted. Steam sand driers have not been found to give the same satisfaction as the stoves for the reason that the sand is said to be more thoroughly dried by the stoves and gives less trouble in operation on the road. Some good results in drying sand have been had with an adaptation of the rotary mineral roaster.

The sand house at Oelwein, C. G. W. Ry., is at the extreme end of the station, and is so arranged that the green sand is shoveled from the car into an inclined

hopper, from which it is let into the heaters by the operator. From the heaters it drops to a lower tank, and is then raised by air pressure to the dry-sand bin at the end of the trestle. From the latter it discharges by gravity to the engine sand-box through a 4-inch pipe and controlling valve.

CINDER PIT.

The method most widely used for handling ashes from locomotives is by means of the depressed track cinder pit. It is thought by many to be more satisfactory for the general requirements than any form of more elaborate equipment, provided it can be made long enough to handle a sufficient number of engines at one time. The amount of depression and the depth of the ash pit are almost invariably controlled by the problem of drainage. Both are made as low as possible so as to avoid any excessive lifting of the ashes. Air hoists are used in some cases for raising the ashes from the pits and depositing them in the cars. Electric cranes also are used, and a special form of traveling hoist is found at some points. This latter is so arranged in its relation to the coal supply cars and ash pits that it can with its clam-shell dipper coal up the engines directly from the cars as well as take the ashes out of the pits. These special forms of ash-handling devices are ordinarily adopted only when the space allowable will not permit the use of a suitable depressed pit. Their details also are specially adapted to the individual plant.

At some roundhouses there are short cinder pits in out-bound tracks for cleaning ash pans of out-bound engines and for cleaning fires of switch engines.

The most desirable location for the cinder pit is as near the roundhouse as possible in order to reduce to a minimum the movement of locomotives after the fire has been knocked out.

At the 1906 convention of the Traveling Engineers' Association the committee reporting on the care of locomotive boilers suggested that on arrival at terminals the fire should not be knocked out on an outside pit; but that cinder pit buggies should be provided in every roundhouse pit, so that if it is necessary to knock the fire, the engine can be run into the desired pit and the fire knocked into the buggy. After knocking the fire the ash pan dampers should be closed, the stack covered and the engine allowed to stand until wanted.

STAND PIPES.

The proper location of stand pipes is at points where they may furnish water to engines on both in-bound and out-bound tracks.

INSPECTION PITS.

At several large terminals elaborate inspection pits have been installed to provide an opportunity for engineers and inspectors to examine all parts of a locomotive immediately upon its arrival at the roundhouse tracks. This method provides for promptly forwarding reports to the roundhouse foreman, in order to eliminate unnecessary delay in making repairs while preparing a locomotive for its return trip. A pneumatic system provides a means of sending reports from the inspection pits to the roundhouse foreman's office.

STORAGE TRACKS.

A comparatively recent innovation is the provision of engine storage tracks on which locomotives that do not require boilers to be washed or repairs to be made, are held under steam and awaiting orders, thereby relieving congestion in the roundhouse and reserving the roundhouse as a repair shop and not as a storage shed. Where space permits the most satisfactory arrangement of storage tracks is in a gridiron form and so connected with lead tracks that any desired engine may be run out without disturbing the others.

TURNTABLES.

In addition to the turntable serving an individual roundhouse an outside turntable is sometimes installed at one end of an engine terminal yard for the purpose of heading engines in the direction desired and thus relieving the roundhouse turntable.

The report of the committee on locomotive terminal facilities, presented before the American Railway Master Mechanics' Association, in 1905, recommended a turntable not less than 85 feet long. The turntable installed at the Elkhart roundhouse of the L. S. & M. S. Ry. is 85 feet long, and that of the East Altoona terminal of the Pennsylvania Railroad is 100 feet long. The standard length of turntable adopted by the Erie and the Baltimore & Ohio Railroads is 80 feet.

A table of ample length facilitates the movements of engines in and out of the house, in that the hostler in charge of an engine has greater freedom in balancing an engine on the table regardless of the height of water in the tank, and therefore will "spot" the engine more quickly. A long table further facilitates movement over the table by providing room for a small yard engine when necessary to handle a dead engine.

Where electric power is available both day and night electric motors are most satisfactory as providing motive power for a turntable. Where electric power is not available, good results have been obtained with both gasoline motors and air motors. Push bars for revolving a table by hand are provided in case of accident to the motors or to the mains providing power.

Tracks leading to the turntable are so arranged that those at opposite ends of the table, at any position of the table, are in true alignment. It is generally agreed that frogs are unsatisfactory around a turntable and are expensive to maintain.

CONSTRUCTION OF ROUNDHOUSE.

Roundhouses have been built most commonly with brick outer walls; wooden posts on the inner circle with wooden doors, and with wooden intermediate columns supporting the roof. In recent years concrete has been used extensively in the construction of roundhouse walls and in several instances the walls and roof have been made of concrete with the steel supporting structure entirely protected by concrete against the action of gases common to the roundhouse. While the roof structure

has sometimes been built of steel, it is generally believed that wood is preferable as all material subject to corrosion should be avoided unless thoroughly protected, as in the case of concrete construction. When steel construction is used cast-iron door posts have been recommended as liable to cause least damage to the structure in the event of an accident to the door column. An accident to the cast-iron column will merely carry away a portion of the column, whereas a bend in a steel column would tend to drag down a portion of the roof.

CROSS SECTION.

The best cross section of a roundhouse is far from being determined. The end to be attained is to provide good ventilation; but this has been sought by so many different ideas that there are many cross sections recommended for each of which certain advantages are claimed. Several illustrations are presented in connection with this chapter which are reproduced from drawings of roundhouses that are believes to have given good results.

The cross section of the roundhouse at Elkhart has met with much favorable comment and the experience of several winters with this roundhouse has proved its design very practicable in providing against the accumulation of gas and smoke. The outer circle of the house, in which the smoke jacks are located, a space 45 feet wide, is spanned by a roof in which the ridge pole is 41 feet above the rail and the bottom of the roof truss is 24 feet above the rail. The slope of the roof in both directions from the ridge pole is at an angle of about 35 deg. The roof over the inner circle, a space 45 feet wide, is nearly flat and has a gradual slope from the point at which it joins the higher roof to the door columns. The roof is supported by the brick outer wall, two rows of intermediate cast-iron columns and cast-iron door columns. The distance from the door columns to the inner face of the wall is 90 feet.

At the East Altoona roundhouse, the single row of intermediate columns divides the building into two bays. The main bay, nearer the turntable, is 65 feet wide and the outer bay is 25 feet wide. The steel structure supporting the roof of the inner bay is 35 feet 6 inches above the rail and the bottom of the roof truss is 30 feet above the rail. The roof of this bay has a gradual slope in each direction from a monitor above the center of the bay, which encircles the entire house. The bottom of the roof truss in the outer bay is 18 feet above the rail and the roof has a gradual slope from the outer wall, a point 26 feet above the rail, to the structure of the inner bay joining it at a point about 2 feet below the bottom of the roof truss.

The Baltimore & Ohio Railroad standard roundhouse is 95 feet wide with a roof supported by three intermediate columns. The roof has a gradual slope from the outer wall toward the door columns. At the outer wall the roof is about 30 feet above the rail and at the door columns, the roof is about 22 feet above the rail. The smoke jacks extend through a monitor encircling the roof on a center line 25 feet from the inner face of the wall.

The cross section of the Erie standard roundhouse is similar to that of the B. & O. However, the slope of the roof is reversed and the height of the roof at the door is 25 feet 5 inches and at the outer wall 19 feet 6 inches. This arrangement was provided to drain the roof toward the outer wall in order that drippings from the roof would not accumulate and freeze in such a manner as to obstruct the movement of doors. There is a ventilator over each pit at about the center of the roof span.

This design reverses general practice, as the more usual custom is to build a high wall with windows extending almost to the roof in order to admit light in that portion of the roundhouse in which the forward part of the engine is standing when headed away from the turntable. In order to avoid the accumulation of ice at the doors, drainage from the roof is generally provided for by a gutter around the inner edge, connecting with a down spout leading down inside of the house and connecting with drain pipes leading from the pits.

A cross section representing a design which has been followed on several roads and which seems to meet with favor, provides for the main portion of the roof to slope gradually upward from the outer wall to a point just back of the cab of the average locomotive when standing with its stack under the smoke jack and headed away from the turntable. The roof over the inner portion of the house in which the tanks stand, is lower than the main portion and slopes toward the doors. The vertical portion of the structure between the two sections of the roof is equipped with swinging glass sashes, thus admitting light at a point above the cab and adding to the means of ventilation.

LIGHTING.

A roundhouse has been described as "a semi-circular structure with a questionable roof, surrounded by all walls and no light." Doubtless such a description applies to many roundhouses. Nevertheless, the necessity of good natural lighting, and the added efficiency to be gained thereby, has been duly recognized and roundhouses may now be seen in many parts of the country where ample provision has been made to admit natural light.

Where proper provision is made for natural light, the greater amount is admitted through windows in the outer wall. It is general practise to head engines away from the table when standing in the house and light admitted through windows in the wall has its greatest effect near the forward part of the locomotive and around the machinery. Light admitted through the upper portion of the windows is diffused over a greater distance and the most satisfactory results are obtained from those windows which extend almost from one pilaster to the next.

At some roundhouses the doors contain as much glass as is consistent with good construction and where there is wall space above the doors this space is fitted with glass as well. Monitors in the roof frequently have

glass sides and there are occasional examples of skylights in the roofs parallel with the pits. A complete circle of glass sash in the upper portion of the roundhouse, between two sections of the roof on different levels, has given good results.

The efficiency of skylights in the roof where the glass surface is flat or nearly so, has been questioned because of the tendency for the glass to become dirty, in view of the generally smoky atmosphere surrounding an engine house. It is conceded that best results are obtained from glass in a vertical plane.

Artificial light in the up-to-date roundhouse is provided by electric lamps. A common custom is to provide arc lamps in the outer circle near the wall and to suspend three incandescent lamps between pits throughout the house. Objection has been made that arc lights cast a shadow which tends to throw a portion of the house in darkness, and to obviate this it has been suggested to light the outer circle with clusters of incandescent lights arranged at intervals along the wall. An additional advantage claimed for this method is that a greater portion of the wiring could be carried along the outside of the walls, with leads to the several clusters passing through pipes inserted in the wall.

Portable lamps are used extensively in fireboxes and other points where light is inaccessible and suitable connection plugs are located on posts between the pits.

Inasmuch as an engine terminal is as busy during the night as in the day time, the yards, coaling station, cinder pits, etc., are lighted artificially by arc lamps.

HEATING.

The method of heating roundhouses which has received greatest favor is the system of delivering hot air through ducts. The air supply is taken from the exterior of the building; is heated by passing through a system of steam coils and is delivered from the point of supply by a fan. The coils are usually heated by exhaust steam from the engine operating the fan. The delivery ducts are usually carried around the house beneath the floor and just within the outer wall. From the main ducts lead connections are made between every alternate pair of pits and hot air is delivered to each pit through two openings in one side, so located that the blast will strike an engine where it will work to best advantage in melting ice formed on the machinery. Dampers placed in the openings at the pits serve to regulate the flow of air at each pit. The circulation of hot air through the house results from the heated air rising and escaping through ventilators and smoke jacks. This is considered more satisfactory than attempting to secure a horizontal movement of the air by mechanical means. The report of the committee on recommendations relative to the requirements of a modern roundhouse, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association in 1905, particularly specifies that "no re-circulation of air should be allowed."

Many roundhouses are heated by direct radiation from coils of steam pipe arranged along the sides of the pits, and the Parsons roundhouse of the M. K. & T. Railway is heated by a gas furnace and direct air heater in connection with a fan system.

VENTILATION.

Ventilation is provided for in roundhouses according to various methods. In some houses ventilators for disposing of steam and gases are placed in the roof immediately above and parallel with the locomotive pits; in others a monitor in the roof encircles the entire house, about midway between the two walls; in still others the entire roof or a portion of the roof is built with a high pitch in order to provide a large volume of space with high head room so that gases will readily rise away from the floor and escape through monitors or specially designed jacks.

The smoke jacks in the Elkhart roundhouse of the L. S. & M. S. Railway are of wood and rectangular in form. Around that portion of each jack that extends above the roof, is a box with a space of about 6 inches between the box and the jack on all sides. This space is open at the point of juncture with the roof and the draft caused by this chimney around the jack tends to remove all smoke and gas which accumulates in the upper portion of the house.

By delivering air in the pits either by direct radiation or by hot air ducts, the heated air is not only directed where it will do most good in melting ice on a locomotive, but the hot air naturally rises and the tendency is to carry the gas, smoke and steam with it. The exterior air entering beneath the doors, etc., naturally tends to rise toward the jacks and ventilators with the air inside of the building.

DOORS.

Roundhouse doors are generally made of wood with a portion of the door including an area of glass sash for the admission of light. Wooden doors are considered preferable, both on account of cost and resistance to corrosion, when compared with steel doors of either the rolling or ordinary type. Swinging doors are usually hinged to swing toward the turntable, though there are instances of doors swinging inward. The swinging door is subject to damage from wind and storm and in the event of its not being properly fastened it is liable to damage from moving engines.

Lifting doors are neater in appearance than the swinging doors, but are more susceptible to minor accidents and are frequently out of order. Lifting doors require a greater height of the house at the inner circle, and an additional height at this point seems unnecessary inasmuch as the tank ordinarily stands near the doors, and there is comparatively little work done in this portion of the house. Door openings are at least 12 feet wide and 17 feet high.

PITS.

In a modern roundhouse capable of caring for large engines of present day service working pits are 65 feet long. The outer end is about 14 feet from the wall and the inner end about 11 feet from the door posts. The

pit tracks extend within about 10 feet of the wall in order that an engine may be moved over a portion of a revolution of a driving wheel if necessary in making repairs. The pit is usually about 3 feet 11 inches wide and 2 feet 6 inches deep at the outer end, sloping to a depth of 3 feet at the end toward the turntable. The best drainage of the bottom of the pit is obtained with a convex floor so arranged that water will run off along the sides of the pit. The bottom, sides and ends of the pit are usually of concrete with a wooden beam along each side to which the rails are spiked.

Each roundhouse has one or more sets of tracks arranged for dropping driving wheels and truck wheels. Driving wheel drop pits and truck wheel drop pits are usually in connection with different working pits, though the same working pits are sometimes equipped for dropping both truck and driving wheels.

Truck wheel drop pits are usually at the end of the repair pits toward the outer wall and the pits are connected by a tunnel. On the bottom of this tunnel is a light, narrow gauge track on which the transfer carriage and jack travel so as to provide for lateral movement when removing and replacing wheels. At Elkhart the truck wheel drop pits are toward the turntable end of the pit and engines requiring wheel work are backed into the house from the turntable. Smoke jacks are placed above both ends of the pits equipped for dropping wheels. At principal roundhouses on the C., M. & St. P. Ry. a pit is put in which is capable of dropping a complete engine truck. The pit is 8 feet 8 inches by 10 feet.

The arrangement of driving wheel drop pits whereby one drop pit includes three repair pits is considered with greatest favor. By this arrangement wheels dropped from engines standing on either of the outer pits may be moved transversely on the jack carriage and delivered to the center track, instead of running the wheels over the floor between pits.

Drop pits constructed on circular lines, on a radius with the center of the turntable as a center, are looked upon with greater favor than those built on straight lines.

At the East Altoona roundhouse of the Pennsylvania four drop pits are installed in the house next to a through running track leading out past the machine shop. One pit is 55 feet long for removing an entire set of wheels under an engine; two have double tables 8 feet 6 inches long for removing a single pair of drivers by dropping the wheels on one table and running them along the bottom of the pit to be raised by the other table; and the fourth is 24 feet long for work on engine trucks, tenders or use in emergency. In addition to these pits a fifth is fitted with removable rails for removing tires without dropping the wheel centers. The tables are lowered and elevated by elevating screws, the operating mechanism being driven by electric motors.

CRANE SERVICE.

Within recent years several roundhouses have been constructed with provision for installing traveling cranes. While the construction of the houses has been arranged for this purpose, the cranes have not always been installed. At the East Altoona roundhouse of the Pennsylvania Railroad provision is made for traveling cranes to span the inner bay—toward the turntable. With this arrangement the crane would not be interfered with by the smoke jacks. The design of the roundhouses built at Pueblo and Denver on the Denver & Rio Grande Railroad, provides for one section of each house to be equipped with a traveling crane. According to this design the crane section is so constructed that the roof over the bay next to the outer wall is higher than the remainder of the roof to provide room for the crane. The flare of the smoke jacks is within this bay and the jacks are so offset that for a short distance they are parallel to the floor and extend upward to the roof in the next bay.

Telescoping smoke jacks have been designed to provide for crane service, and the lower portion of the jack may be lifted sufficiently to allow a crane to pass beneath.

Swinging jib cranes are usually suspended from columns of the outer row in order to serve the forward portion of a locomotive for the purpose of handling steam chest covers, pistons, rods, etc.

At the Rensselaer roundhouse of the New York Central Lines an air hoist is used to remove driving wheels from the drop pit and place them on cars for delivery to the shop.

Frequently a swinging jib crane is suspended from a column near a door for use in loading material upon a locomotive tank for shipment to an outlying point.

FLOORS.

Roundhouse conditions require a good, substantial floor that may be readily drained. Dirt floors are filthy and unsatisfactory. Floors of wooden planks have long been used with success and are still looked upon favorably. Concrete floors have been installed in many roundhouses within recent years and flooring of vitrified brick set on edge in tar has given very satisfactory results. To insure good drainage floors are elevated to a height of two inches above the rail midway between the pits and slope gradually toward the pits.

The report of the committee on up-to-date roundhouses presented before the American Railway Master Mechanics' Association in 1905 suggests "a good floor, adopted by the New York Central for roundhouses, is prepared as follows: Upon a level sub-grade an 8-inch bed of cinders is placed and thoroughly rammed. Upon this is placed a 5-inch layer of concrete, consisting of one part of Portland cement, four parts sand and seven and one-half parts of broken stone. Upon this is a top dressing, one inch thick, composed of one part Portland cement and one part of sand. This is deposited simultaneously with the concrete to insure a perfect bond. The top is surfaced true with long straight edges and is floated to be smooth. Drainage is secured by raising

the floor to a height of two inches above the rails, midway between the pits."

SMOKE JACKS.

The many different designs of smoke jacks in use and the difference of opinion regarding certain makes renders it difficult to determine upon a jack that meets with general favor. To allow flexibility in placing engines as required for different details of repair work it is very essential to provide a smoke jack with a long base in order to increase the scope of its usefulness.

In a paper before the American Society of Civil Engineers, Mr. R. D. Coombs says: "Smoke jacks have been constructed of a variety of materials. Wood, cast iron, tile and asbestos have given satisfactory results. Smoke jacks of thin rolled plate have a very short life and, in the writer's estimation, are not worth installing. Wood lasts rather better than might be expected and, in connection with a fireproof roof, should prove economical and safe. It is not necessary to sand the interior, though the exterior should be well painted.

"Cast iron, if heavy, has a fair length of service. Tile is more expensive, and its weight and liability to break, if detachable, are objectionable features. Asbestos is light in weight and is fireproof, but is more expensive in first cost.

"A telescoping jack, provided with a bell having a diameter of about 4 feet, would be the writer's preference."

TRACK STOPS.

Track stops to provide against engines running beyond the ends of the tracks are wise provisions and have prevented accidents which might have caused damage both to locomotives and roundhouses.

PIPING.

Piping for water, air and steam in the more recently constructed houses is usually carried in ducts encircling the house just within the door columns or within the outer wall. Where the house is heated by hot air delivered by a fan, the hot air duct is utilized for carrying the pipe lines. From the duct the pipes are led to convenient connections on columns between the pits.

BOILER WASHING SYSTEMS.

Several systems of washing and refilling locomotive boilers with hot water and of blowing off boilers without filling the house with steam have been developed. Some of these systems have proven very economical in the expense of washing boilers and in reducing the necessary detention of locomotives at terminals. In addition they have improved working conditions in roundhouses by eliminating fog and steam and further tend to lengthen the life of metal structures by doing away with the presence of moisture liable to cause corrosion.

RECOMMENDATIONS OF THE A. R. E. & M. OF W. ASSN.

The report of the committee on buildings presented before the annual meeting of the American Railway Engineering and Maintenance of Way Association in 1905 recommends that a modern roundhouse be designed and equipped as follows:

(1) That in a circular roundhouse the locomotives should stand in the house normally, with the tender toward the turntable.

(2) That distances from center of turntable to the inner side of roundhouse shall be determined by the number of stalls required in the full circle.

That length of stall along center line of track should not be less than 85‡ feet in clear.

(3) That clear openings of entrance doors should be not less than 12 feet in width and 17 feet in height.

That the angle between adjacent tracks should be an even factor of 180 deg., so that the tracks at the opposite ends of the turntable will "line up" with it.

(4) The turntable should be not less than 75* feet in length. The table should be operated by power, preferably electric.

(5) The material used in construction of the house should be non-corrosive, unless proper care be taken to prevent corrosion.

(6) Engine pits should be not less than 60† feet in length, with convex floor, and with drainage toward the turntable. The walls and floors may be of concrete, and proper provision should be made in construction for the support of the jacking timbers.

(7) Roundhouse doors should be made of non-corrosive material.

(8) Smoke jacks should be fixed, having large hoods; constructed preferably of non-corrosive material and supplied with dampers. The cross-section of the stack should be not less than 30§ inches in diameter.

(9) The floor should be of permanent construction on a concrete foundation and grouted. It should be crowned between pits, and that part adjacent to pits within jacking limits should be of wood.

(10) Drop pits should be furnished for handling truck wheels, driving wheels and tender wheels. These can be most economically constructed in pairs.

(11) If the building be heated with hot air it should be by the indirect method, and the supply should be taken from the exterior of the building (no re-circulation of air should be allowed). The air should be delivered to the pits under the engine portion of the locomotive.

Air ducts should be located under the floor and special precaution should be taken to keep them dry.

(12) As much good light should be obtained from exterior of the building as good construction will allow.

(13) There should be an arc light, and a plug outlet for incandescent lights in each space between stalls.

(14) The contents of boilers should be taken care of and discharged outside of the building in a suitable receptacle and the heat units used as may be deemed best.

(15) Cold water should be supplied at each alternate

*More recent practice indicates 85 ft.—Editor.

†More recent practice indicates 65 ft.—Editor.

‡More recent practice indicates 95 ft.—Editor.

§Unless jack is made to lower and fit over stack a minimum of 42 in. is considered necessary.—Editor.

space between stalls from an outlet not less than 2½ inches, located at a point about opposite front end of firebox; the water pressure should be not less than 80 lbs. The hydrants should be located below the floor in properly constructed pits amply drained.

Modern practice requires the use of hot water in the maintenance of boilers.

(16) Compressed air is used for mechanical hoisting and blowing* operations. Overhead outlets should be furnished in each space between stalls opposite front end of firebox. The pressure should be from 80 to 100 lbs.

(17) A roundhouse should have facilities for the location of a few necessary machine tools, preferably electrically driven.

(18) Air hoists, or portable goose-neck cranes with differential blocks on wheels, should be furnished for handling heavy repair parts.

(19) The turntable pit side walls should be of concrete with wooden coping not less than 6 inches thick, and the ties under the circular rail should be supported on concrete walls. Pivot masonry may be of concrete with stone cap.

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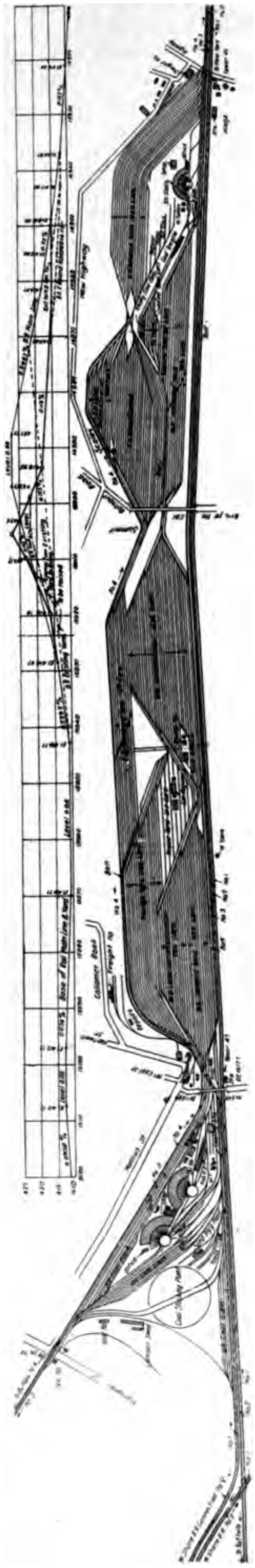
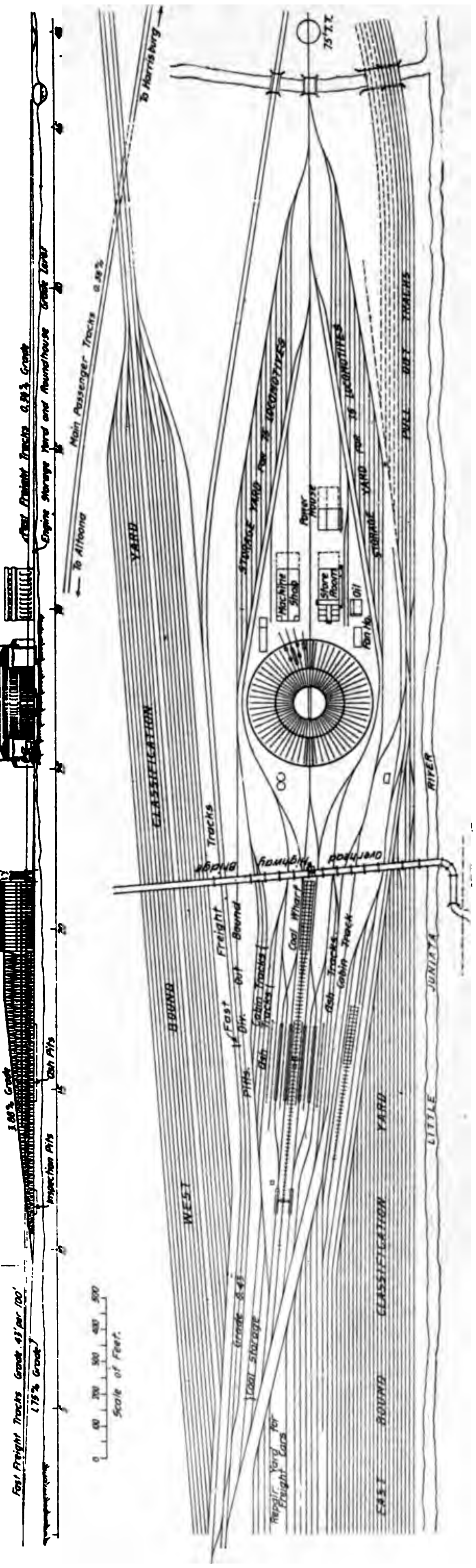
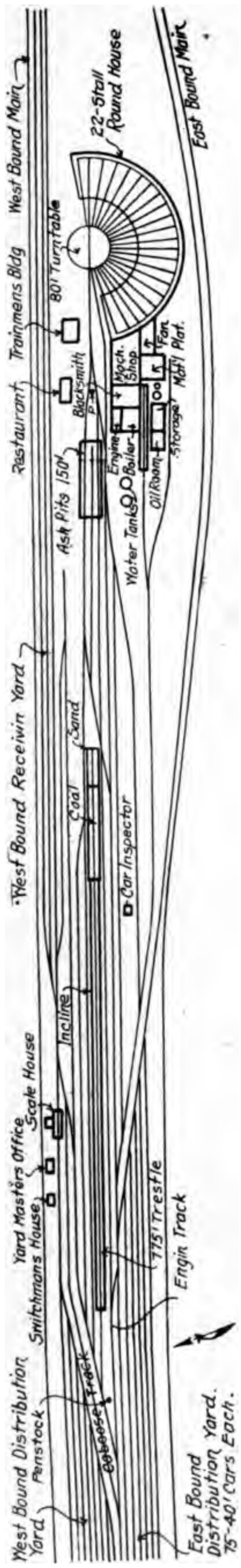
*Steam is considered more economical for blowing.—Editor.



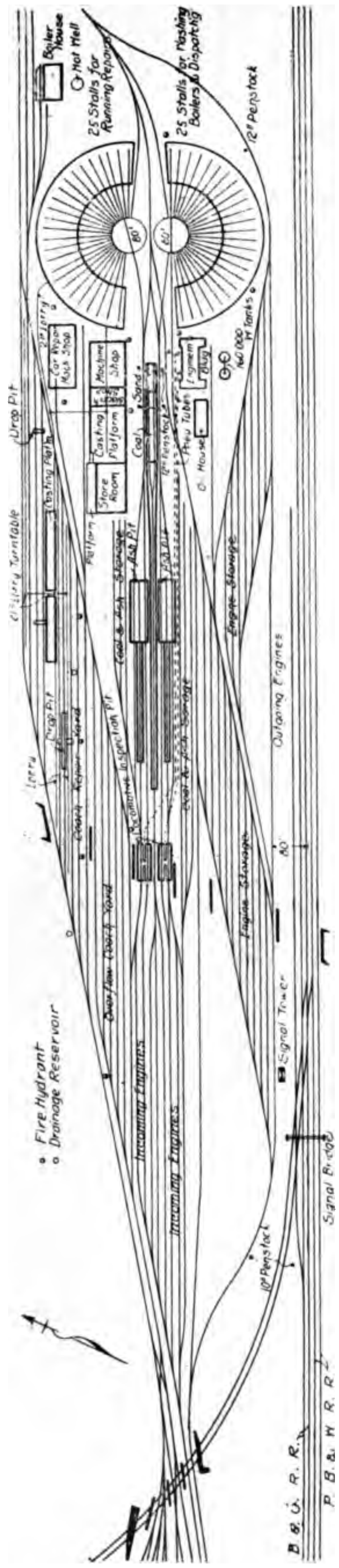
GENERAL LAYOUT OF LOCOMOTIVE TERMINAL AND FREIGHT YARDS AT DEWITT, N. Y., N. Y. C. & H. R. R. R.



GENERAL LAYOUT AND PROFILE OF LOCOMOTIVE AND FREIGHT YARDS AT EAST ALTOONA, PA., P. R. R.



GENERAL LAYOUT OF LOCOMOTIVE TERMINAL AT HOLLOWAY, O., B. & O. R. R.



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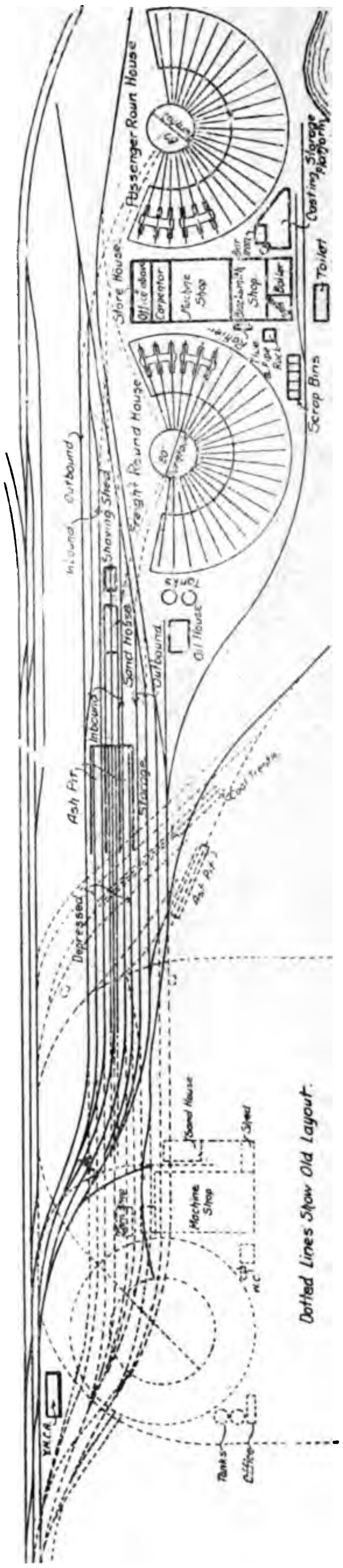

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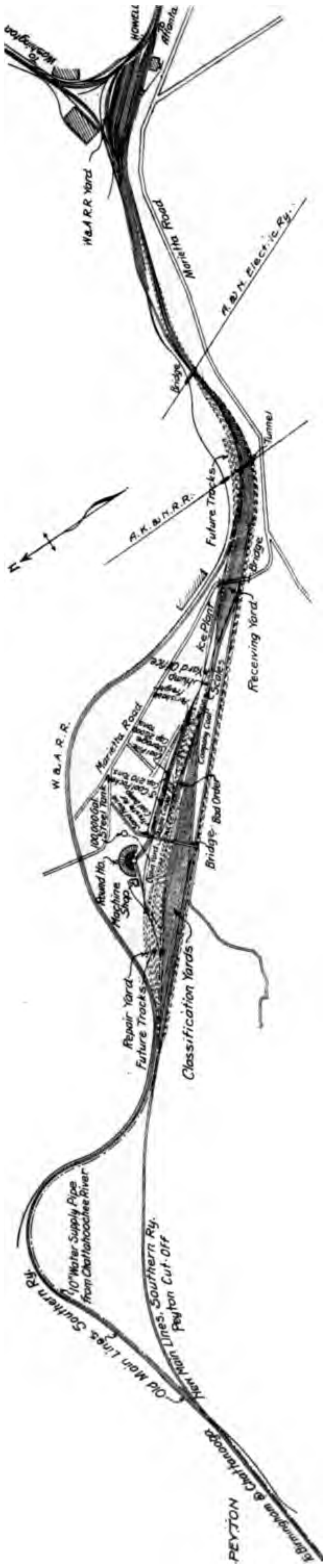
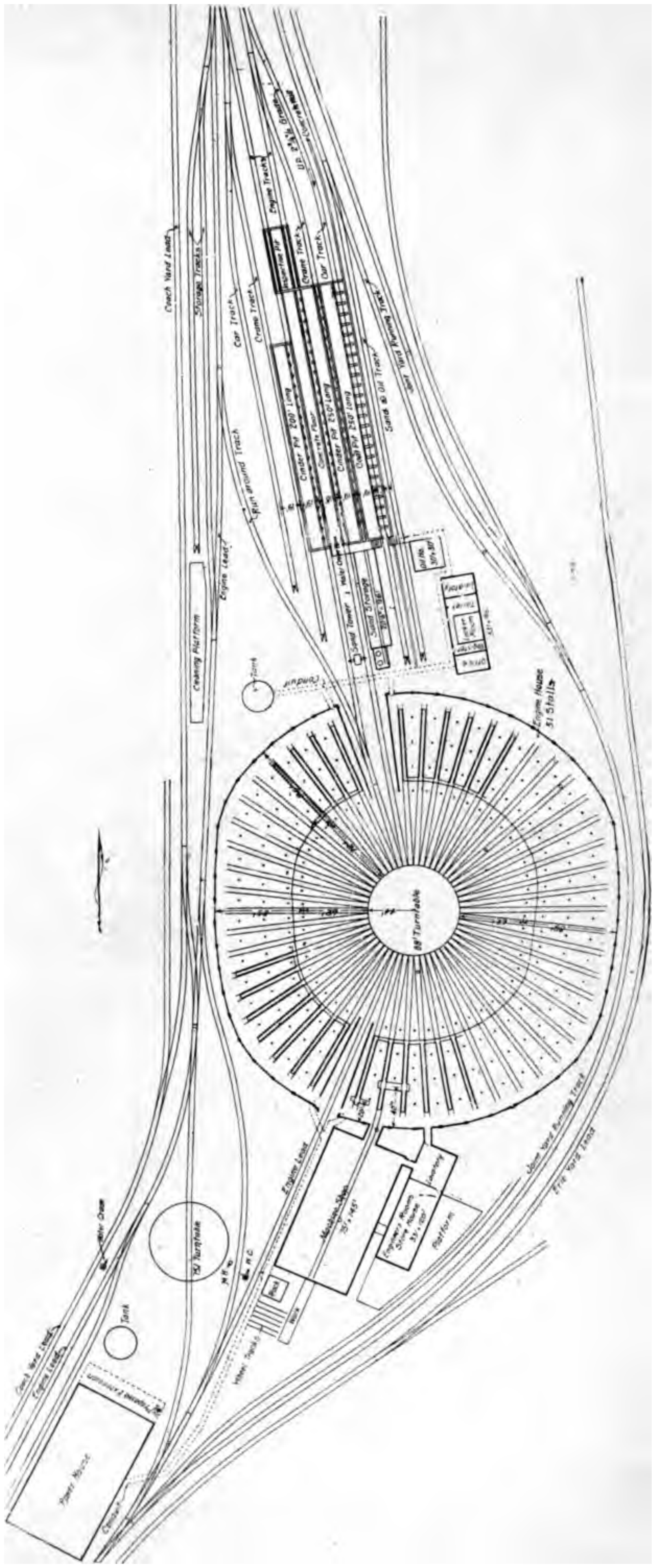


GENERAL LAYOUT AND APPROACHES AT INMAN YARD, SOUTHERN RY.



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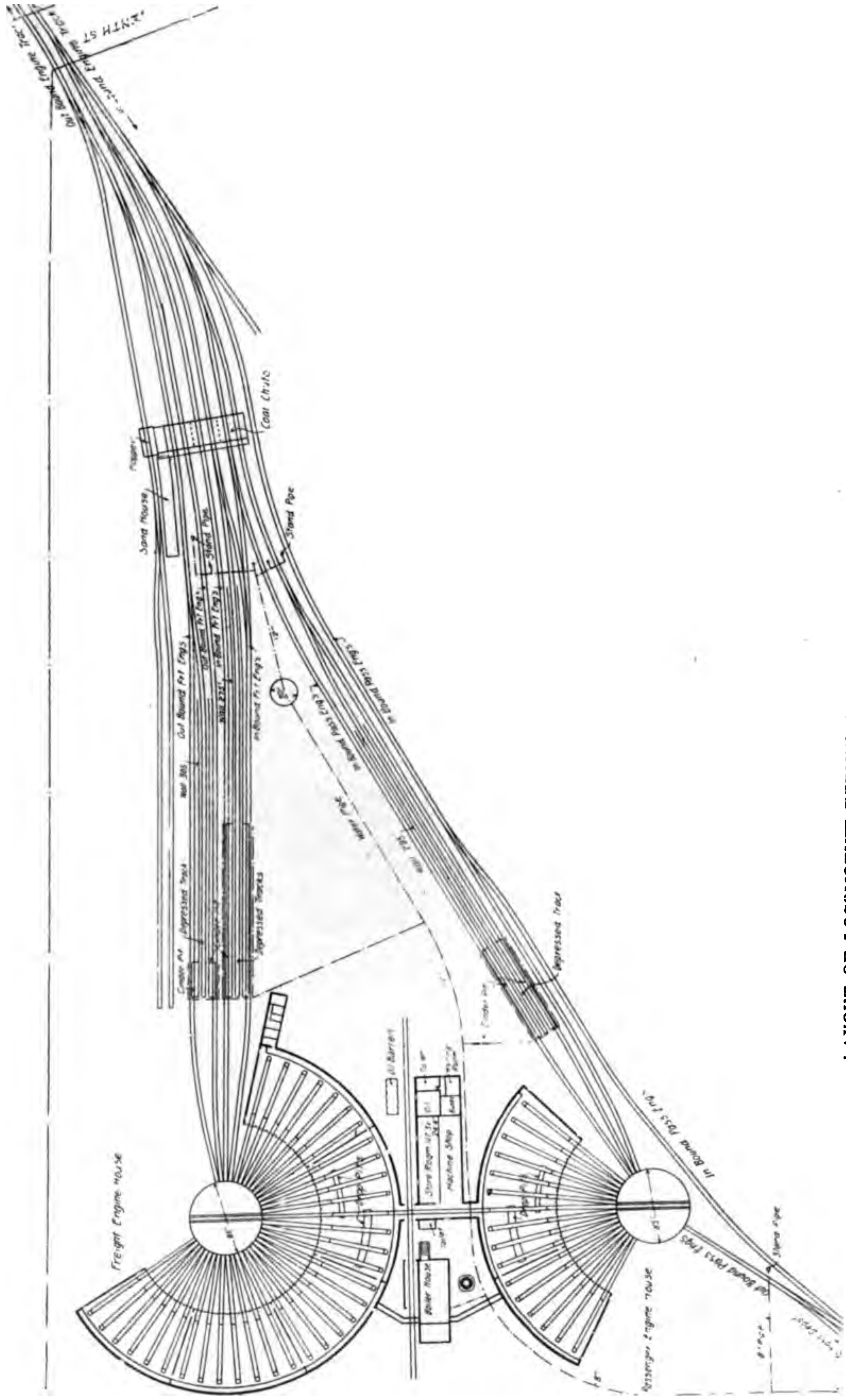
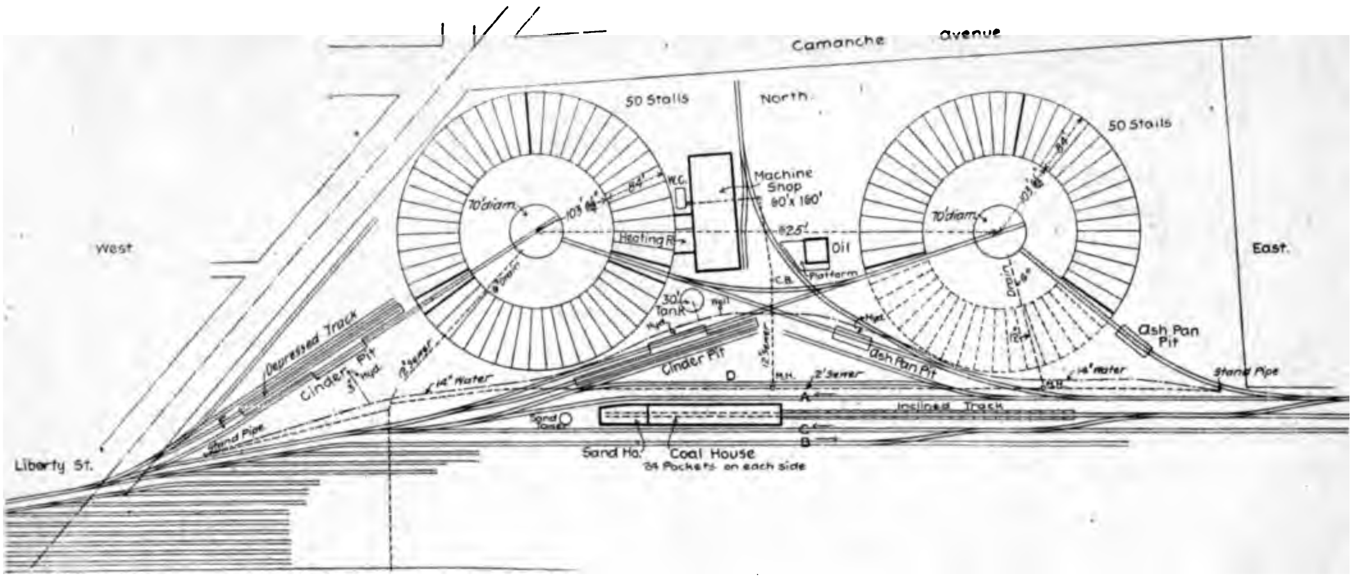


LAYOUT OF LOCOMOTIVE TERMINAL AT ELKHART, IND., L. S. & M. S. RY.



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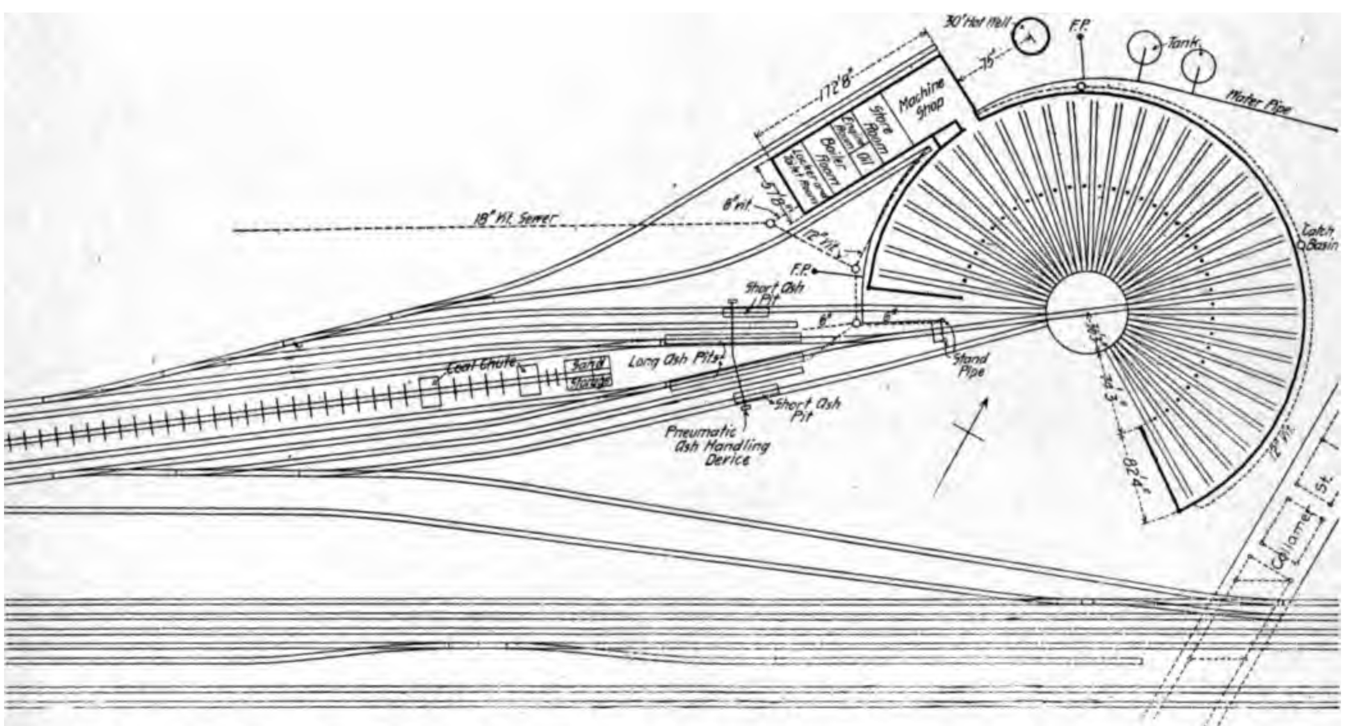

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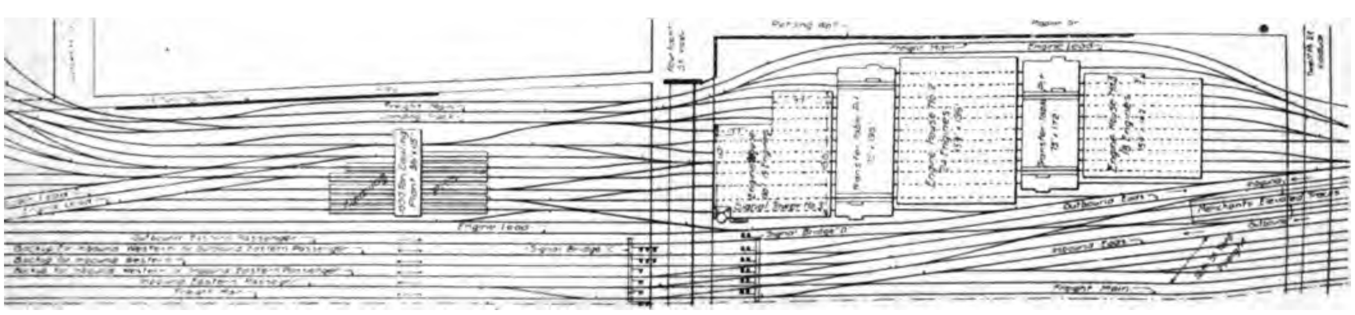

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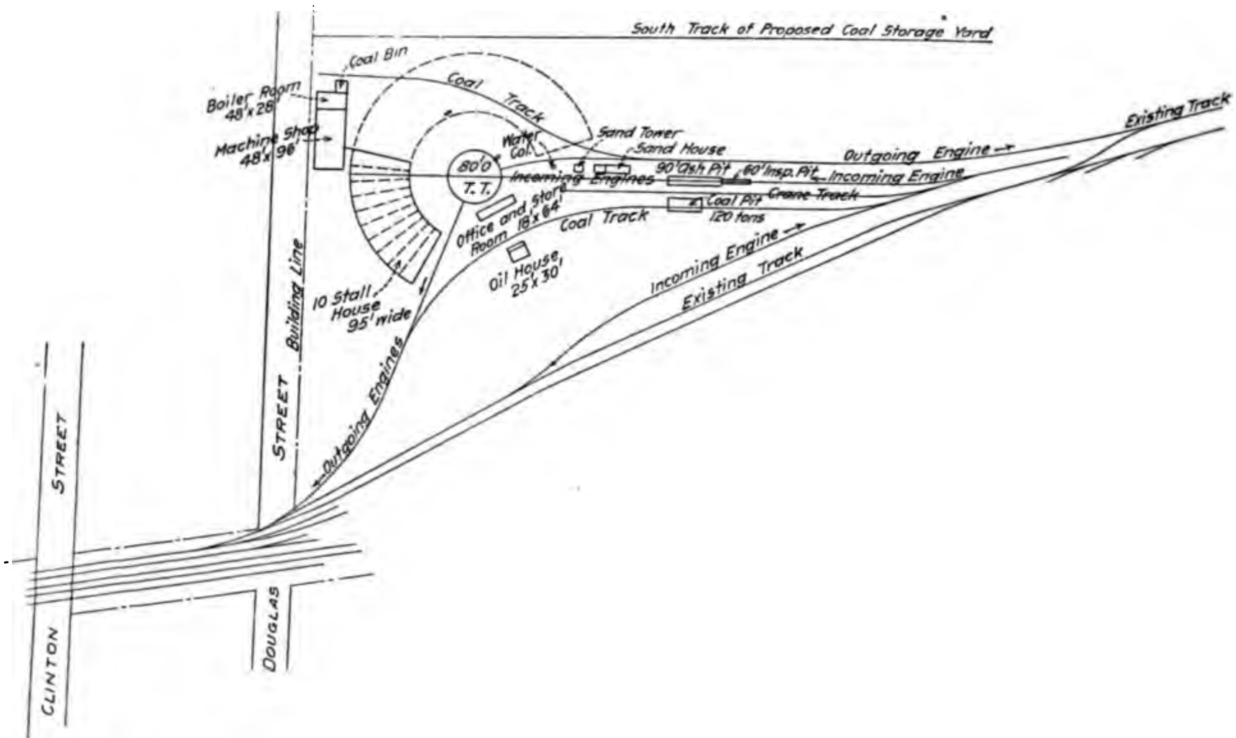

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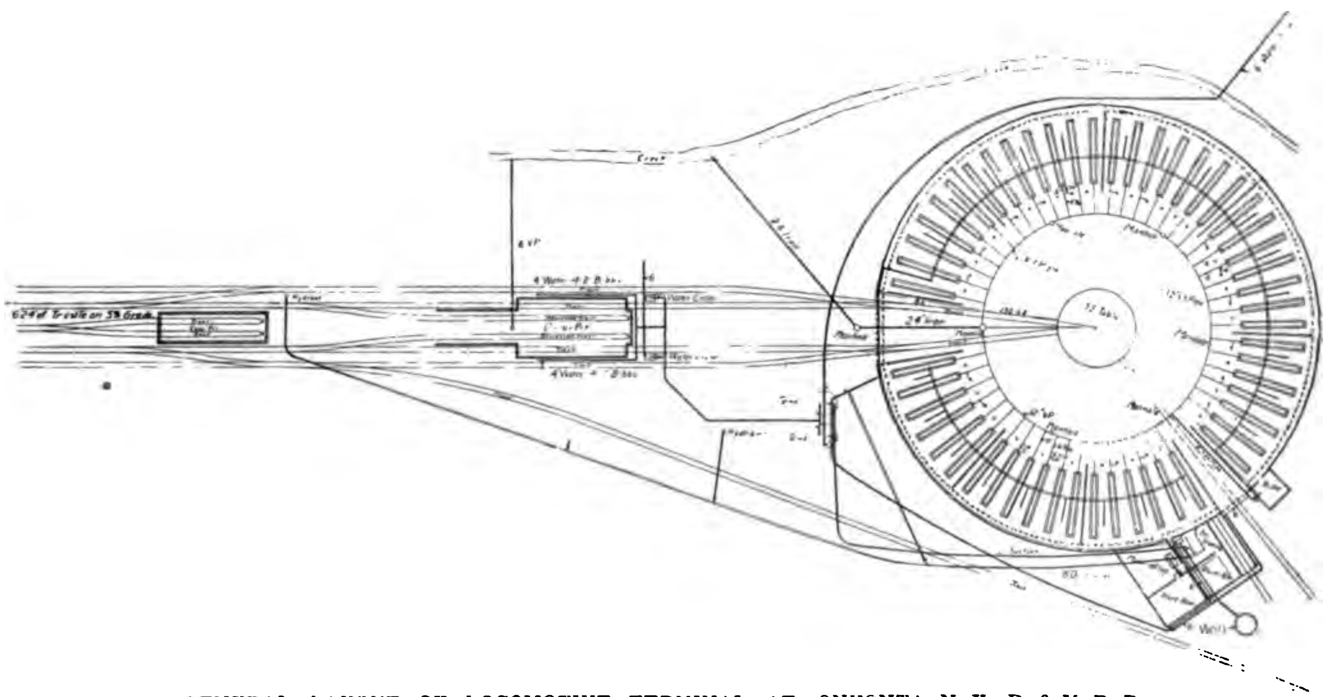

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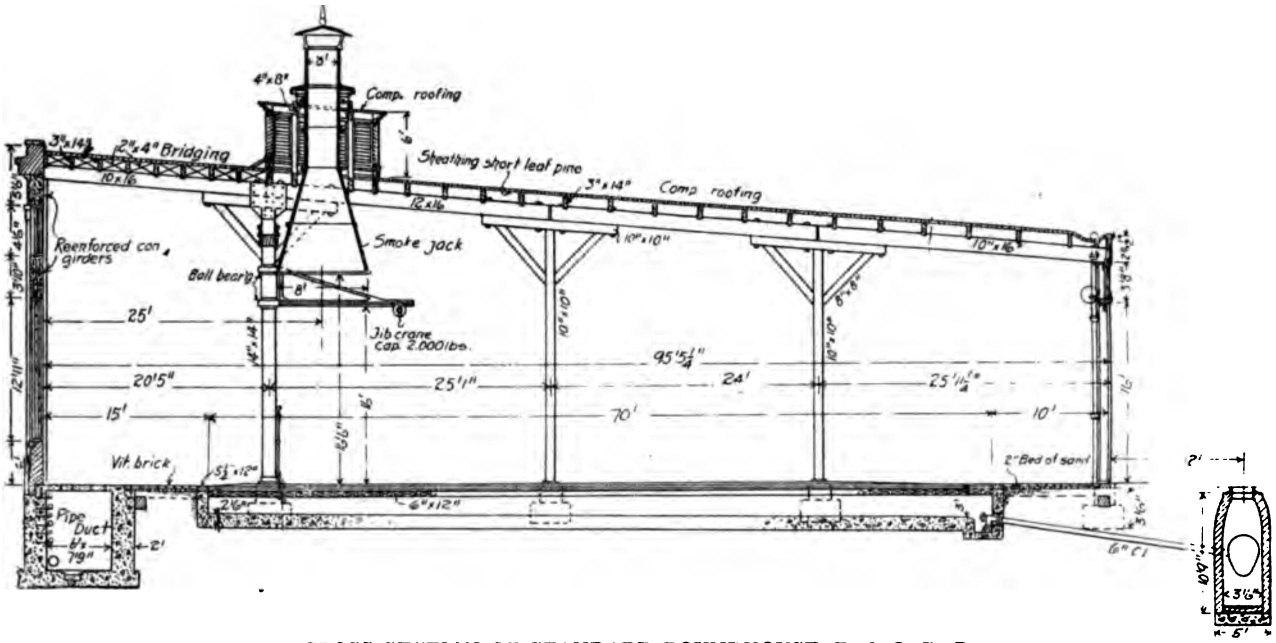
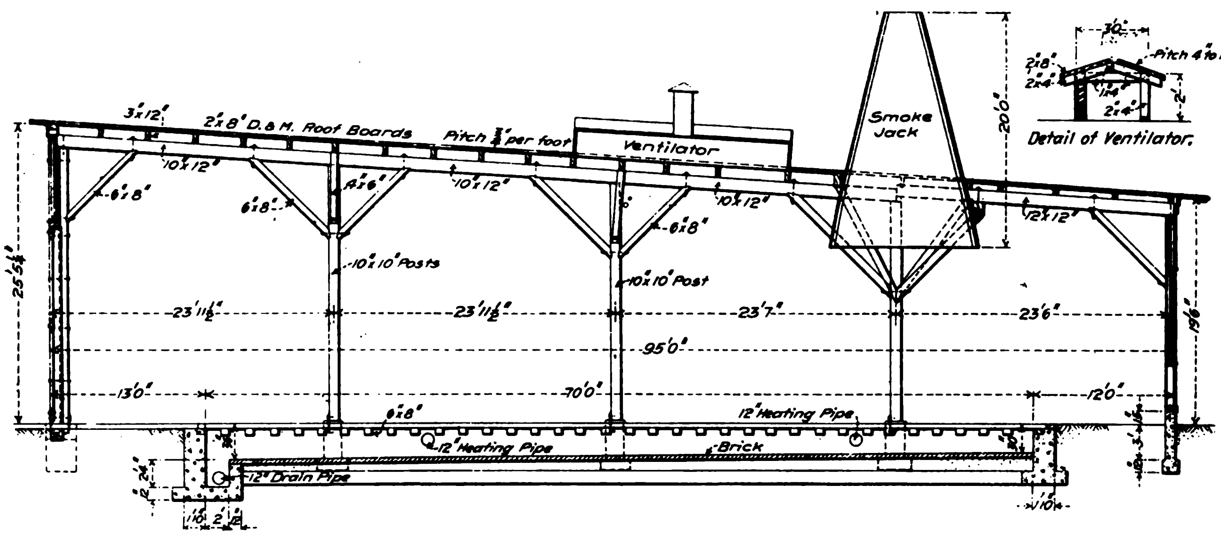


CROSS SECTION OF STANDARD ROUNDHOUSE, B. & O. R. R.



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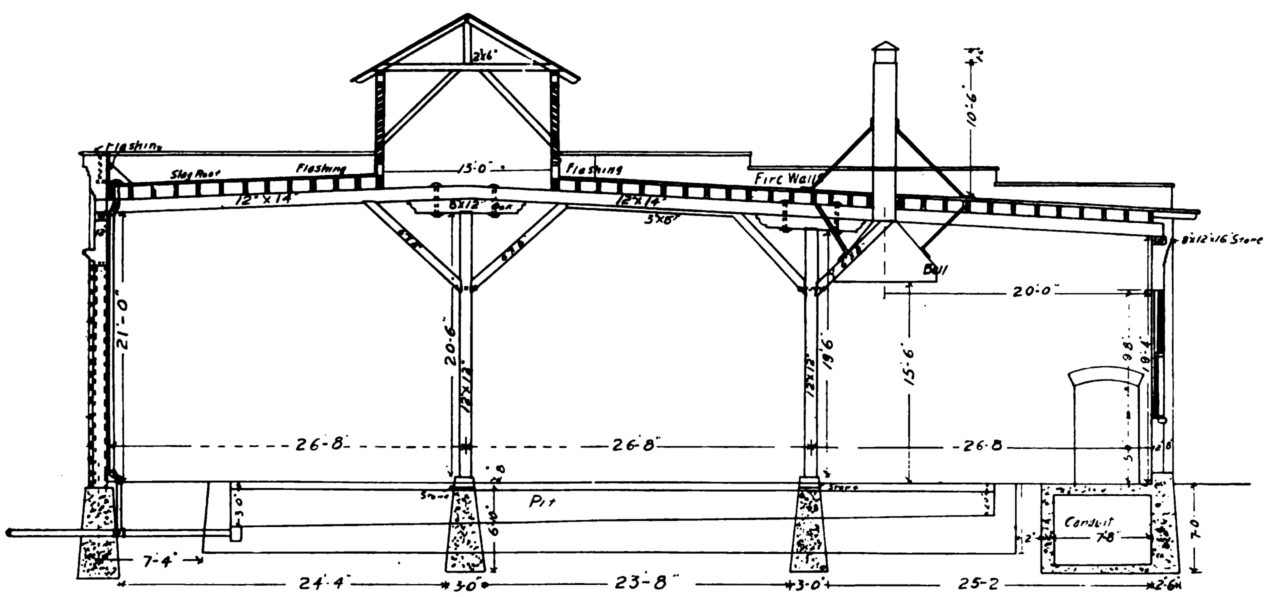

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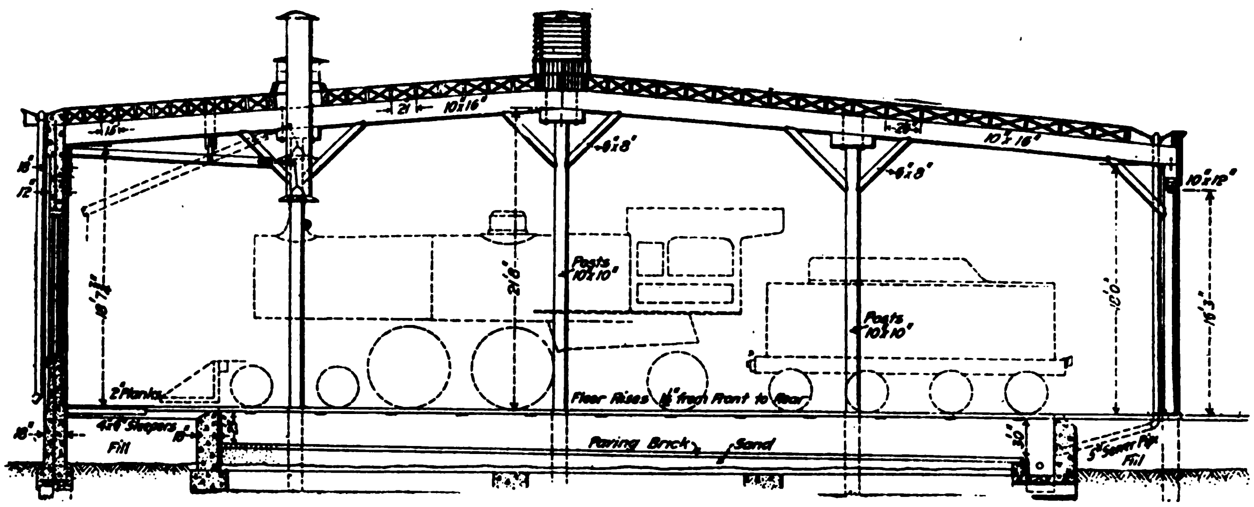

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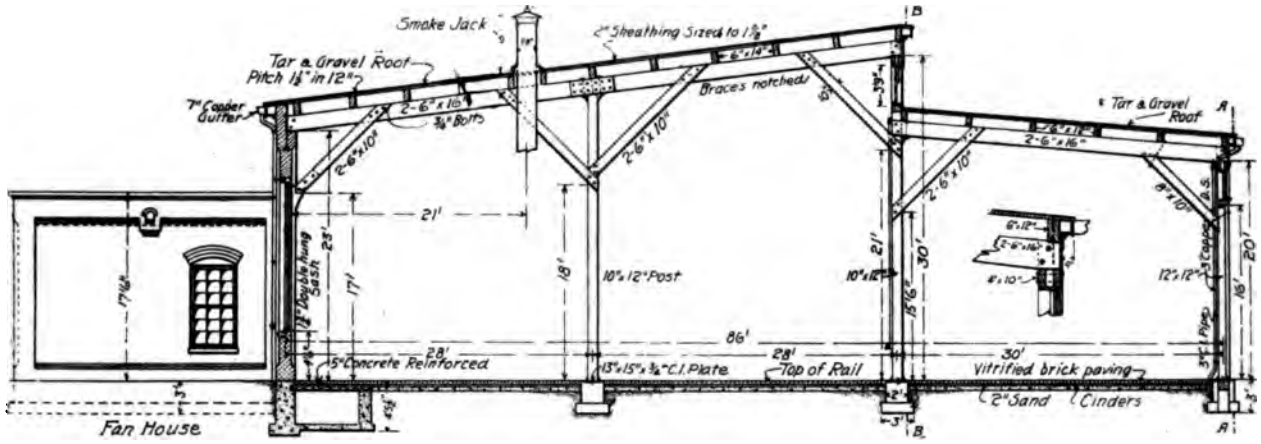

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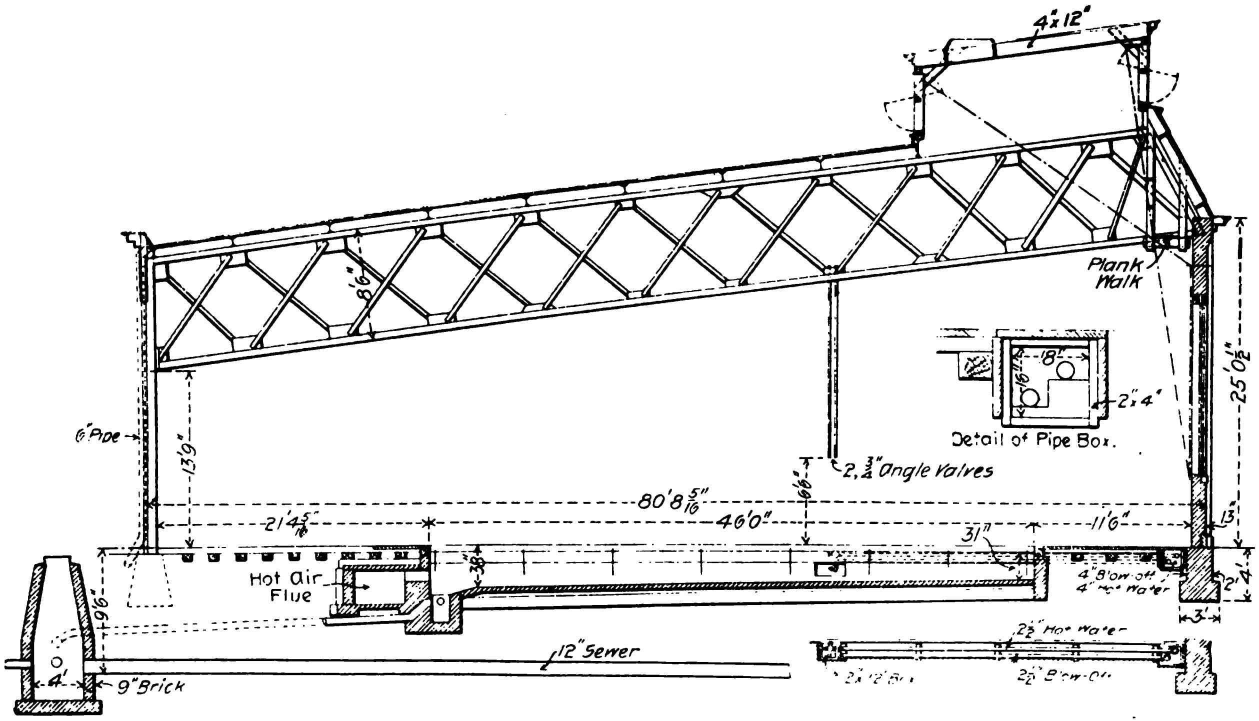

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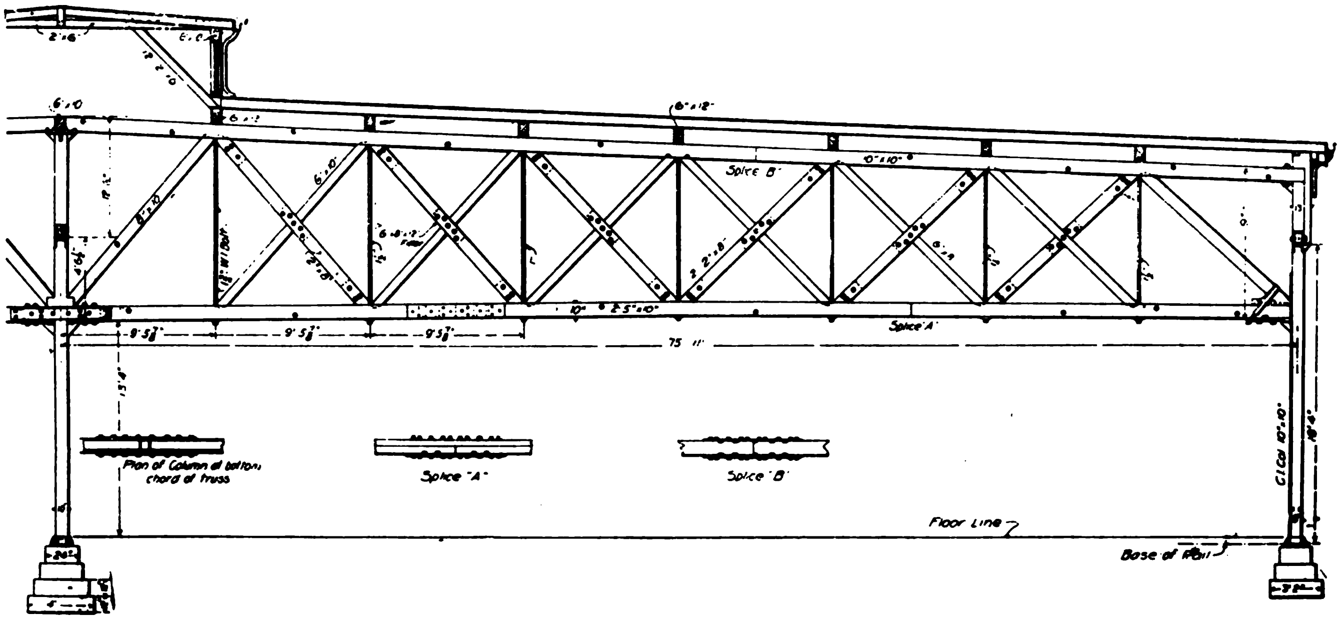
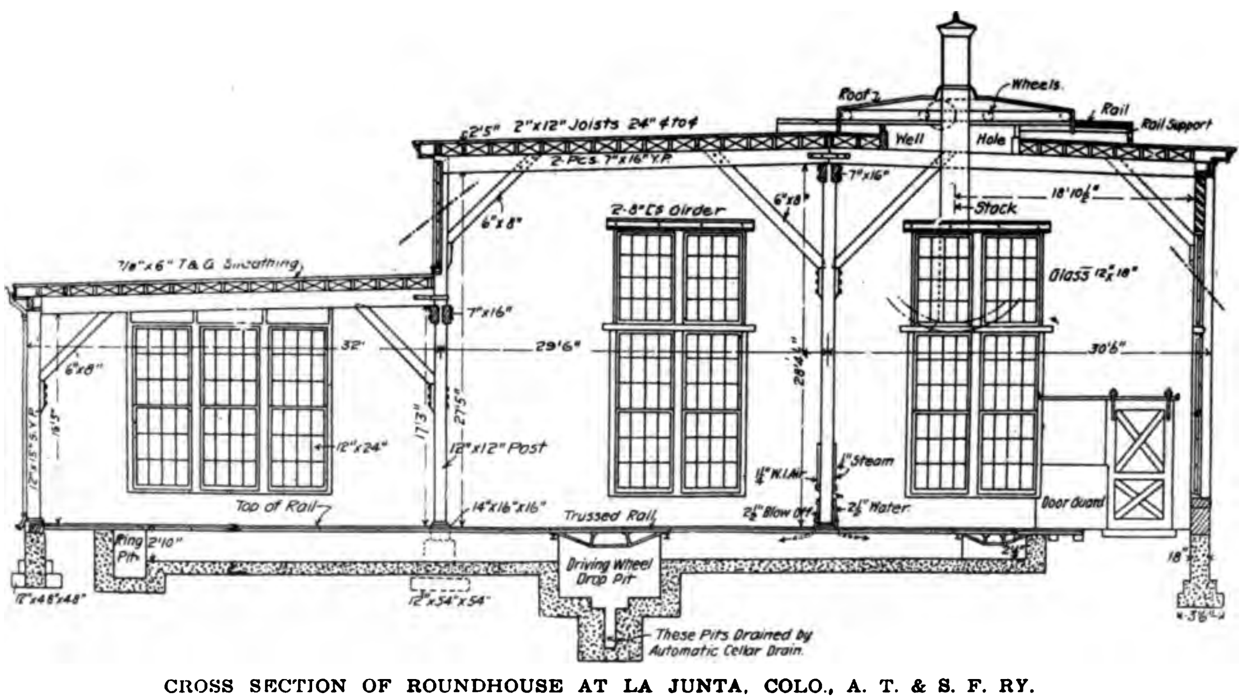


PARTIAL SECTION OF ROUNDHOUSE AT EAST ST. LOUIS, ILL., T. R. R. ASSN. OF ST. L.



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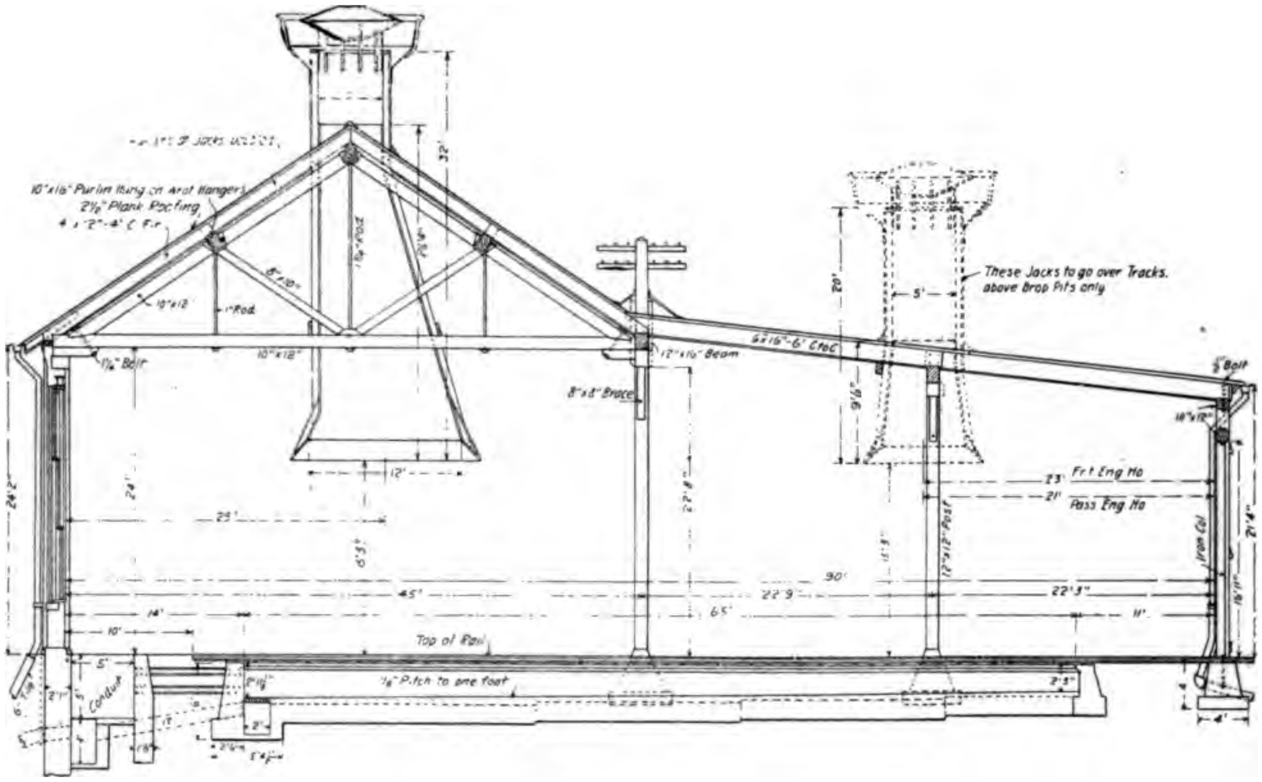

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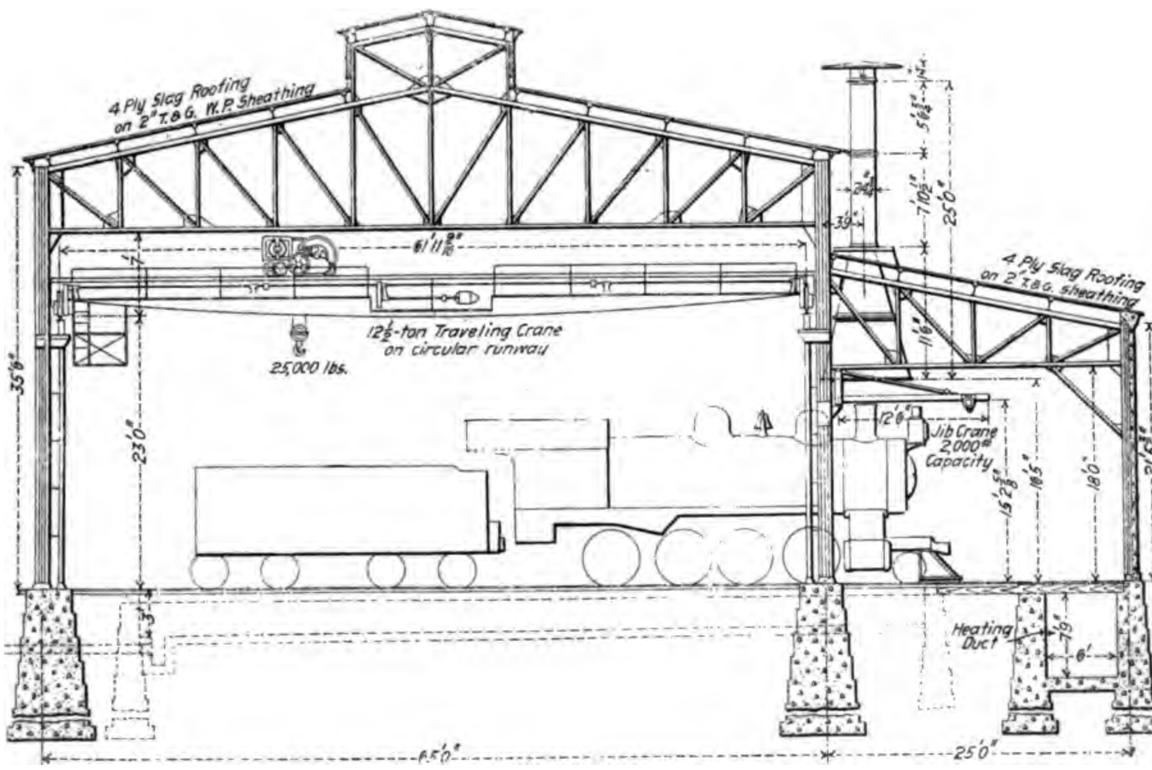

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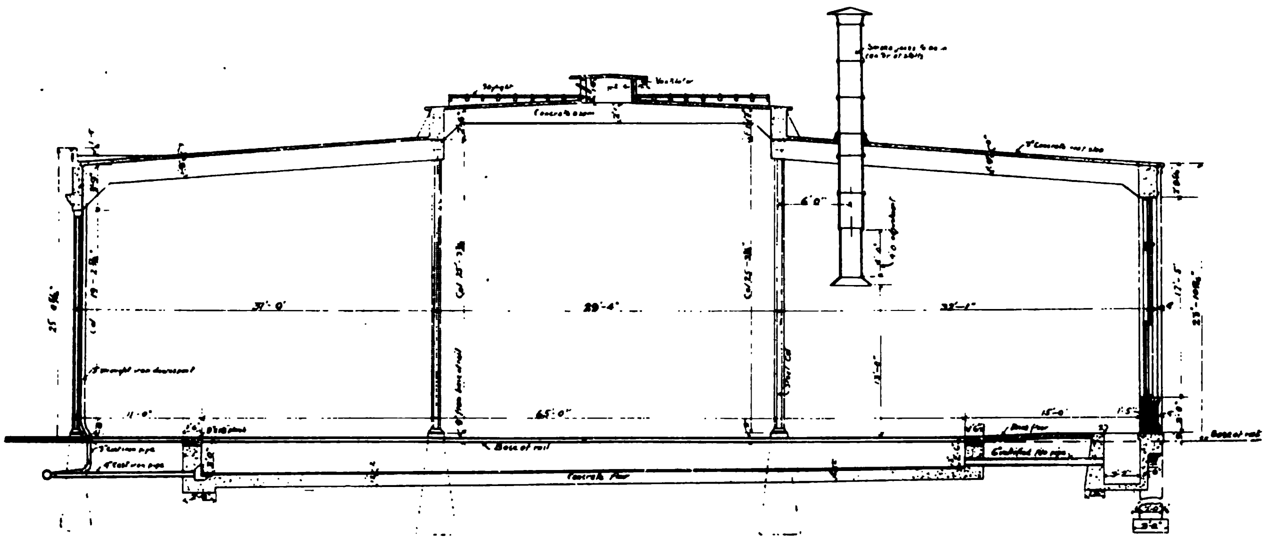

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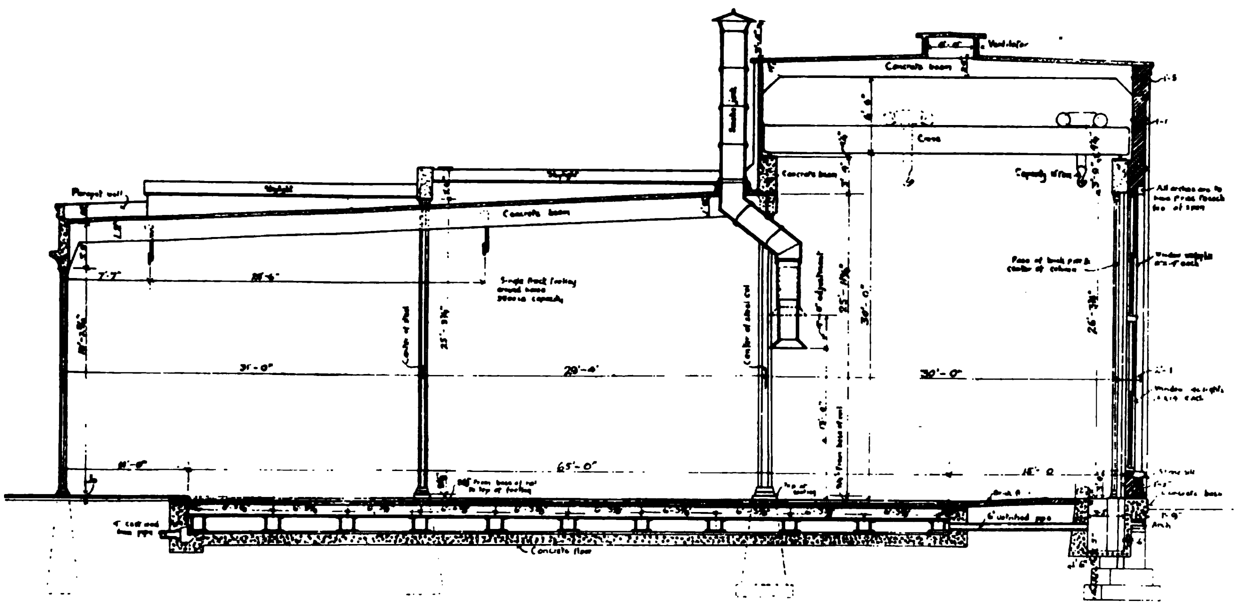

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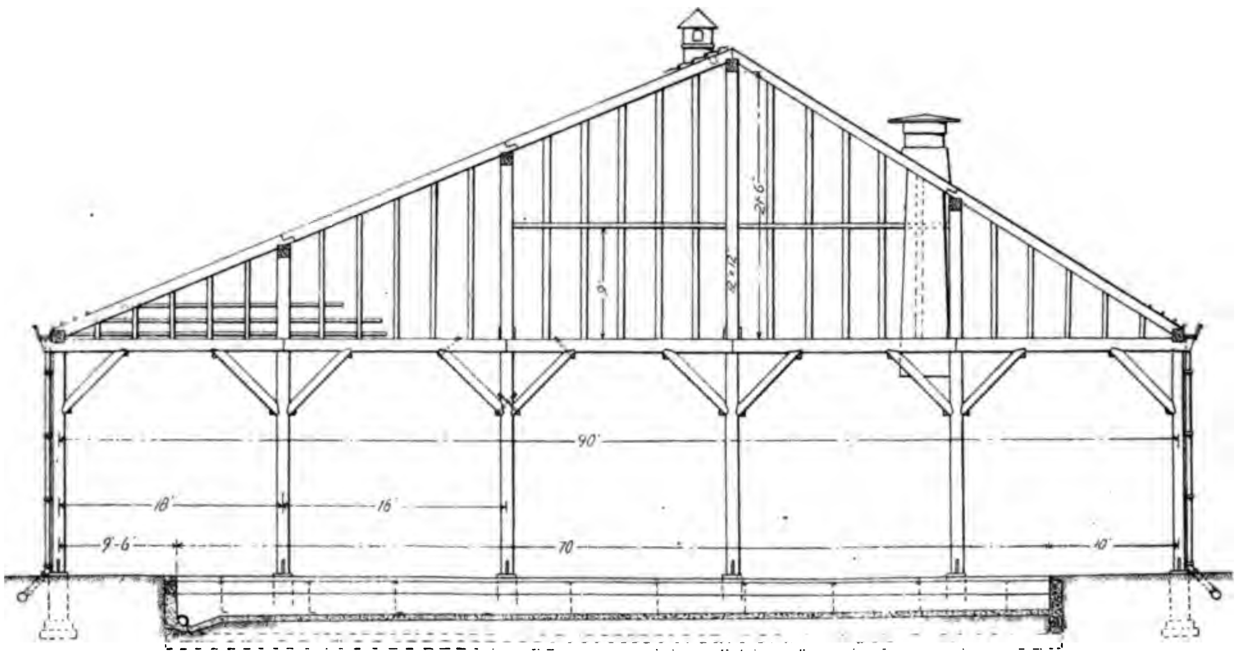

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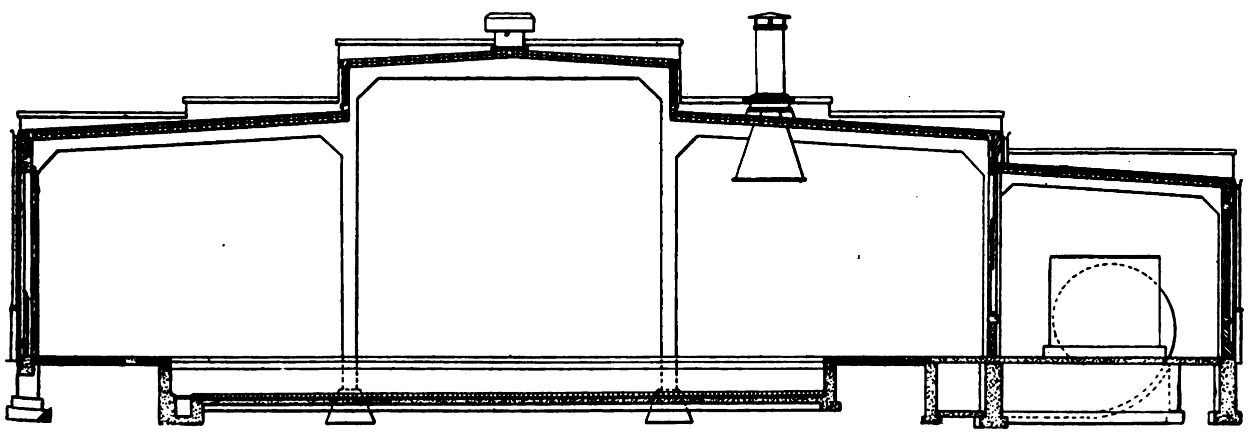
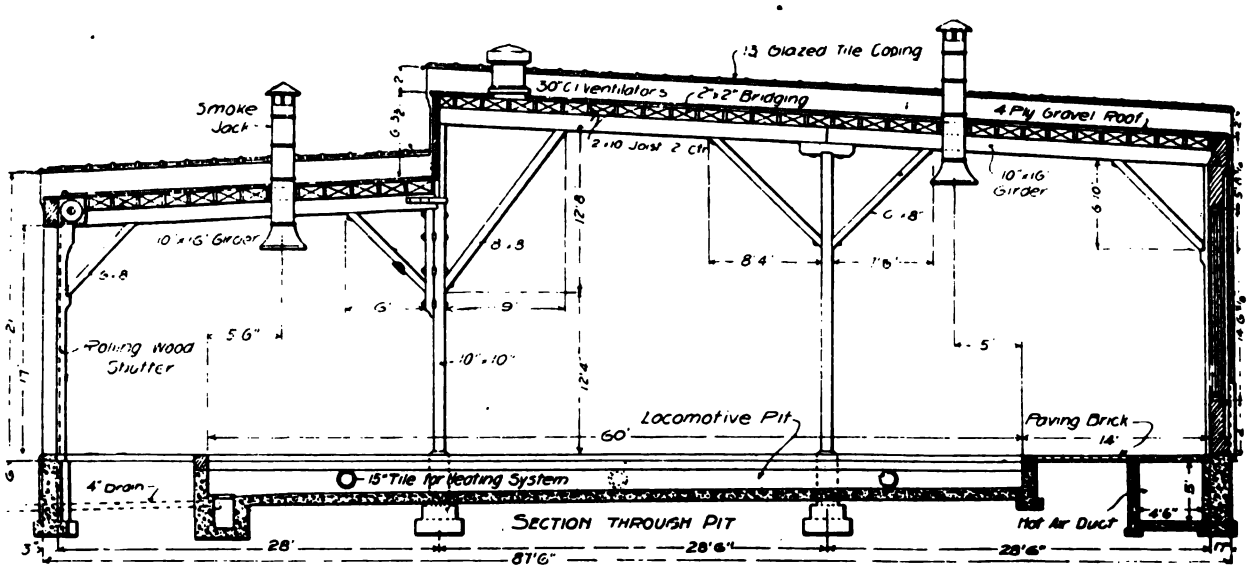
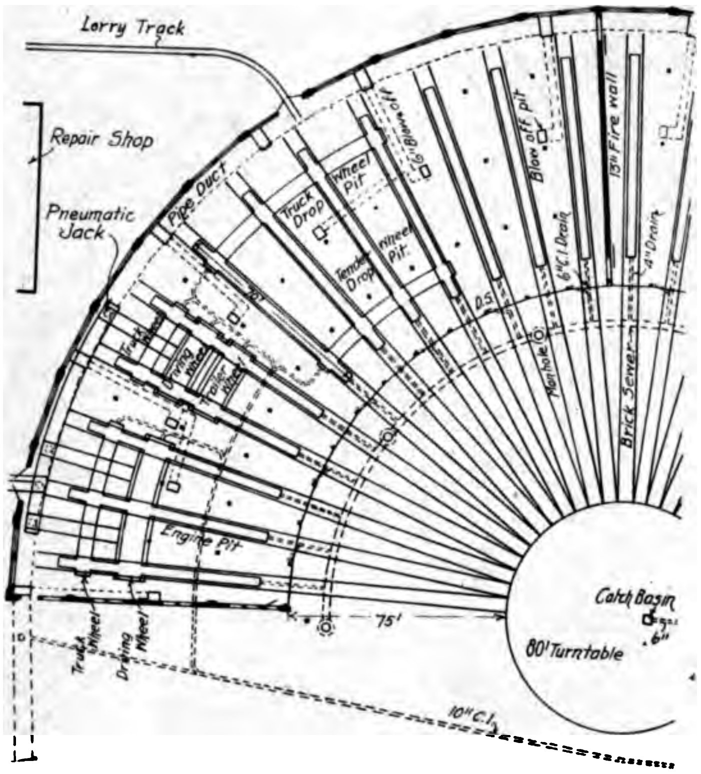


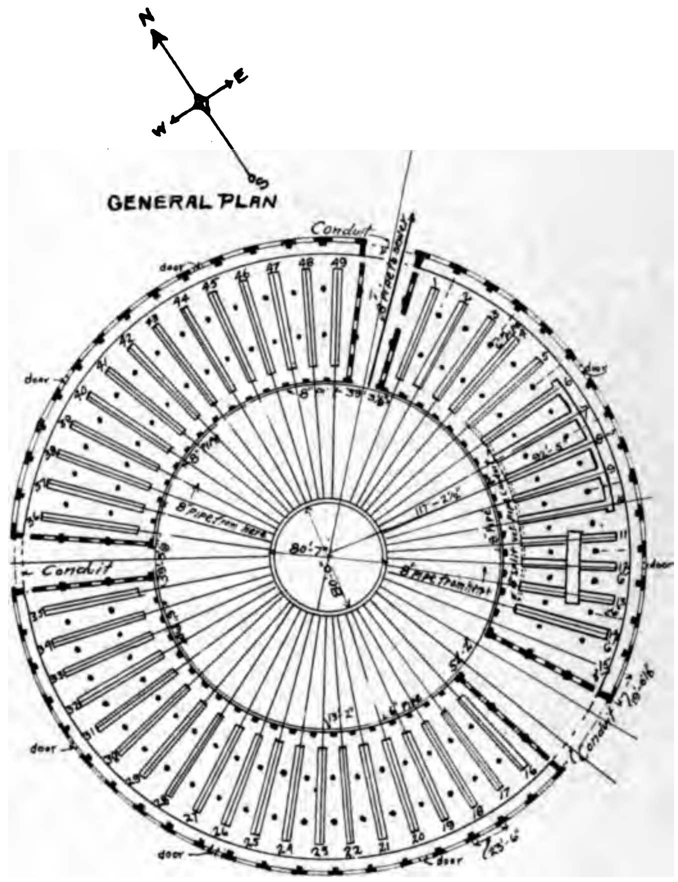
CROSS SECTION OF REINFORCED CONCRETE RECTANGULAR ENGINE HOUSE, C H. & D. R. R.



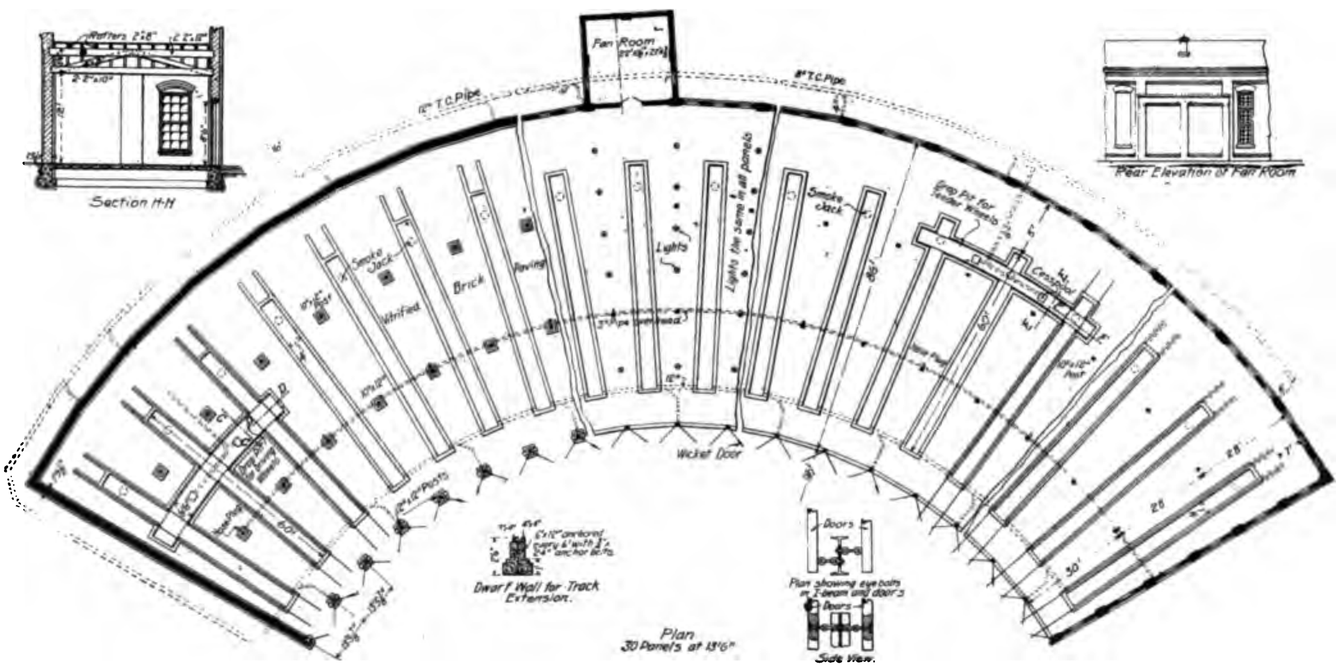
CROSS SECTION OF RECTANGULAR ENGINE HOUSE AT GRAND RAPIDS, MICH., PERE MARQUETTE R. R.



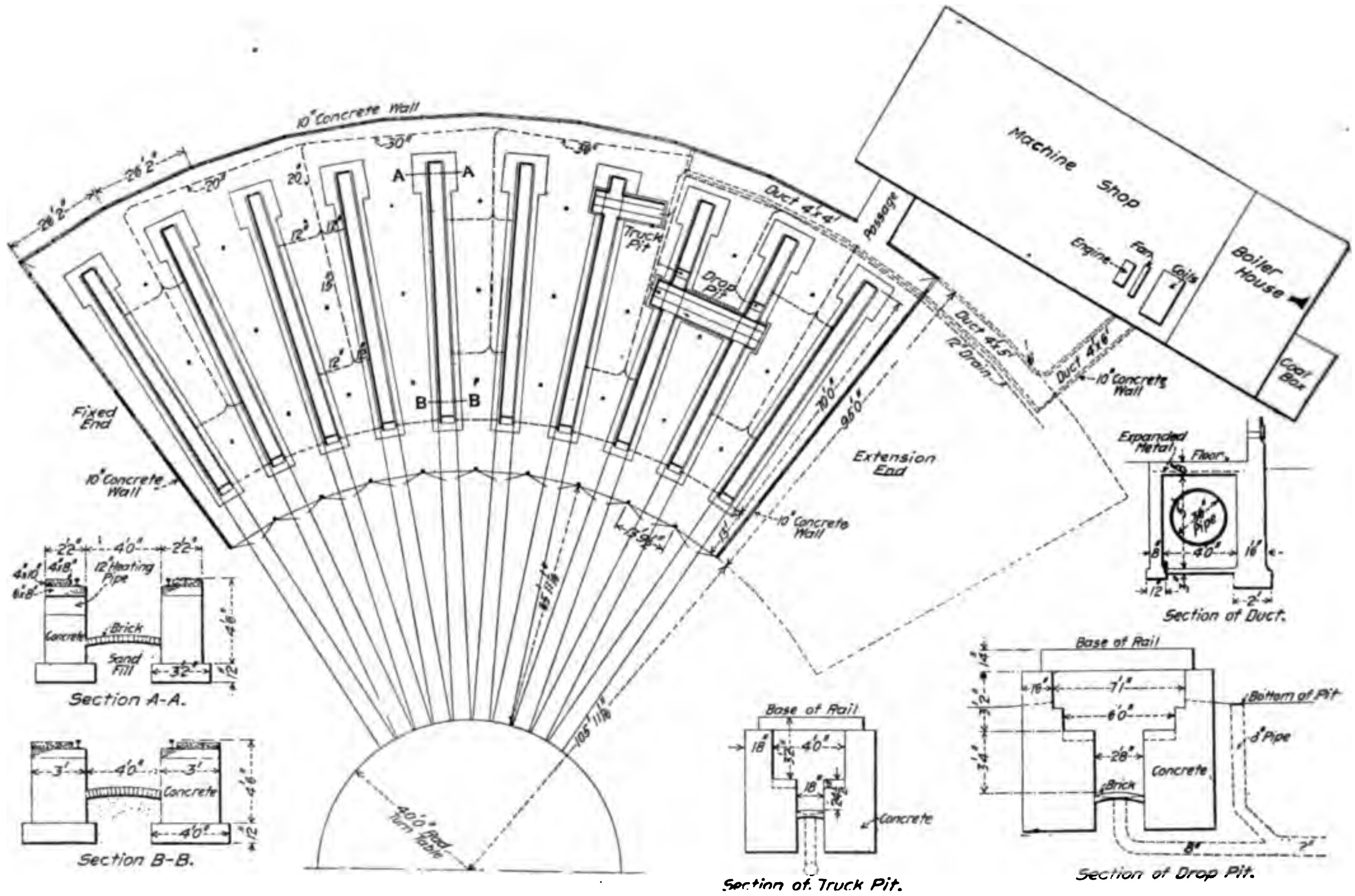
SEGMENT OF STANDARD ROUNDHOUSE OF B. & O. R. R.



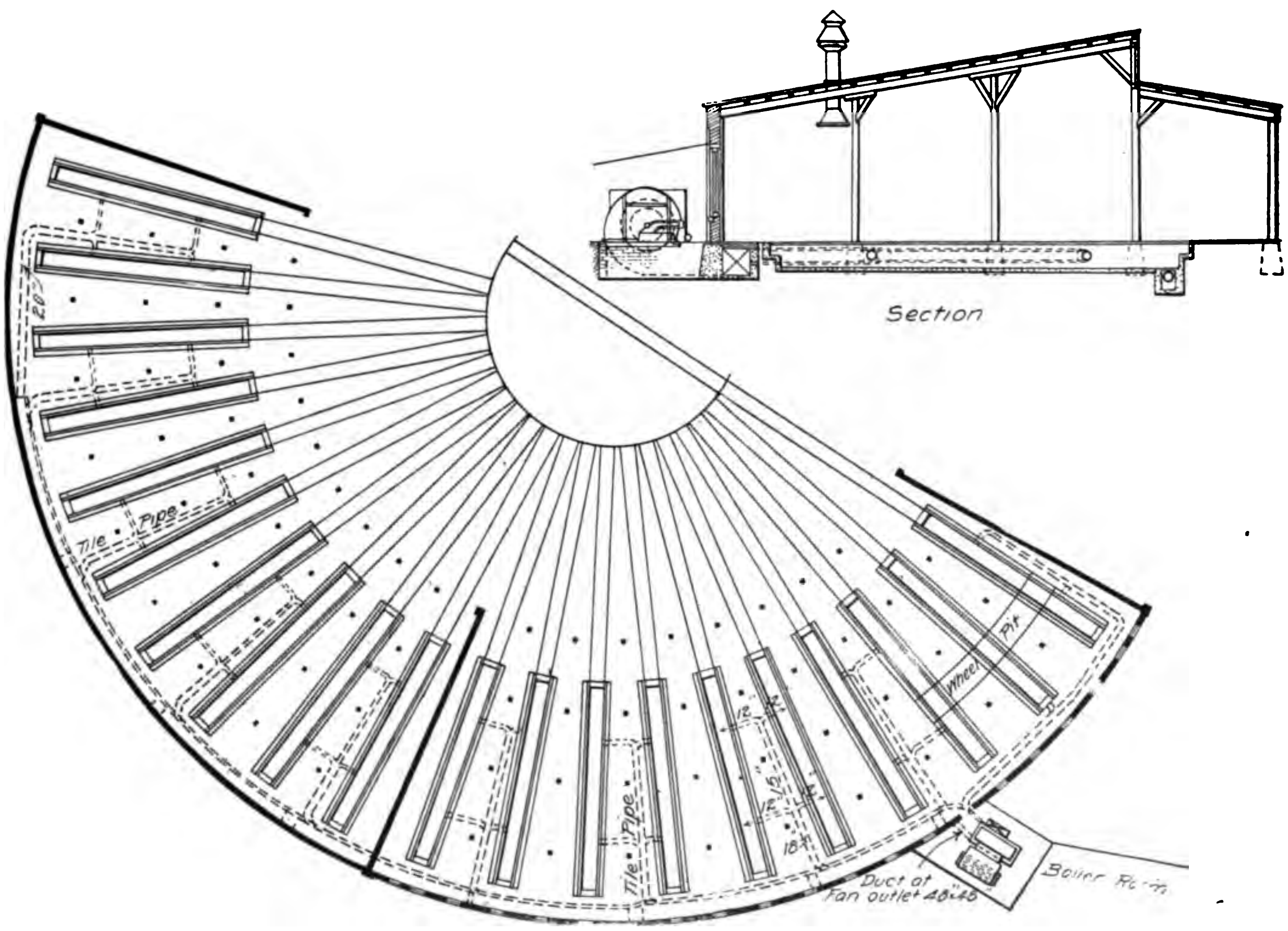
PLAN OF ROUNDHOUSE AT PUEBLO, COLO., D. & R. G. R. R.



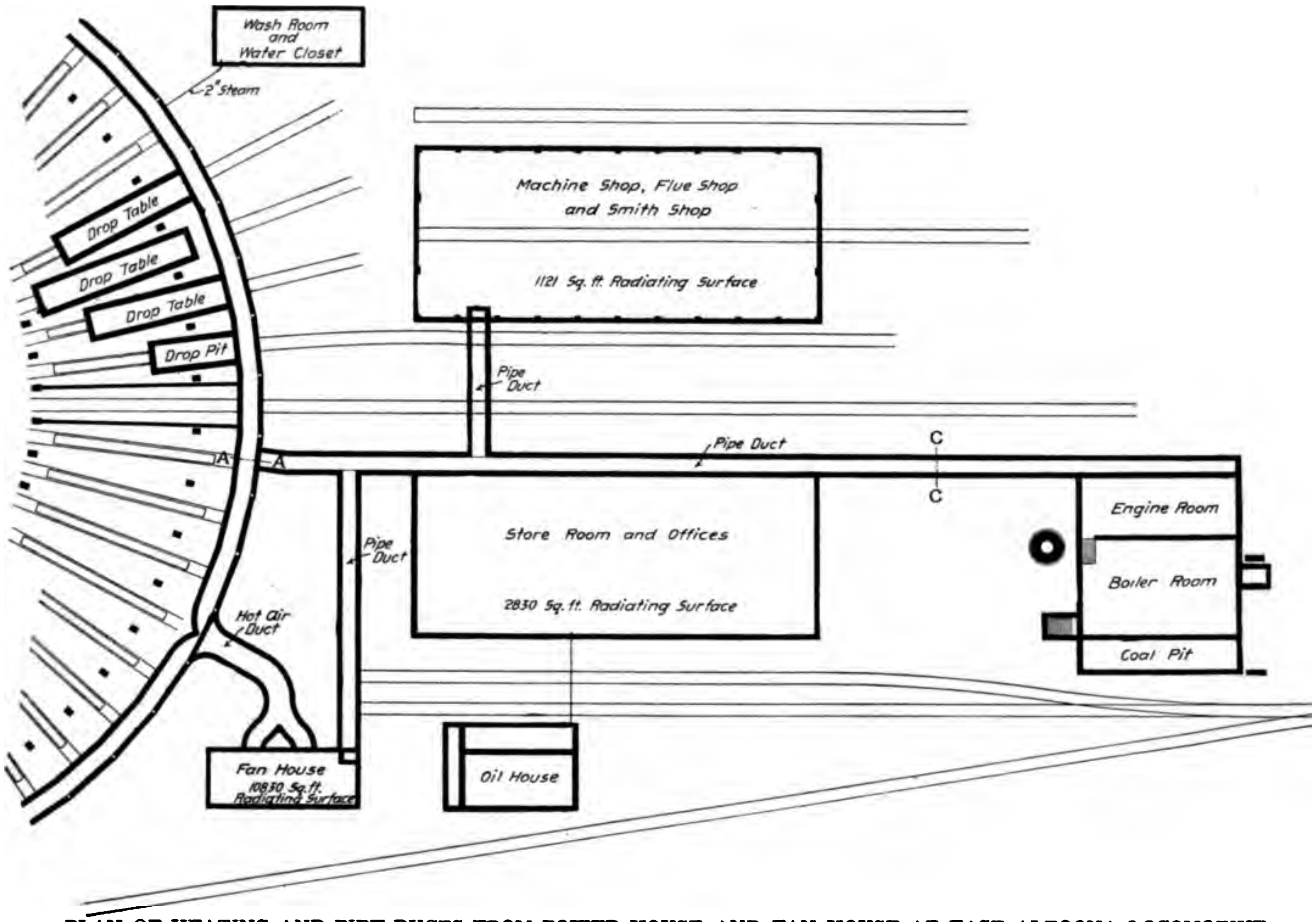
PLAN OF ROUNDHOUSE AT ATLANTA, GA., SOUTHERN RY.



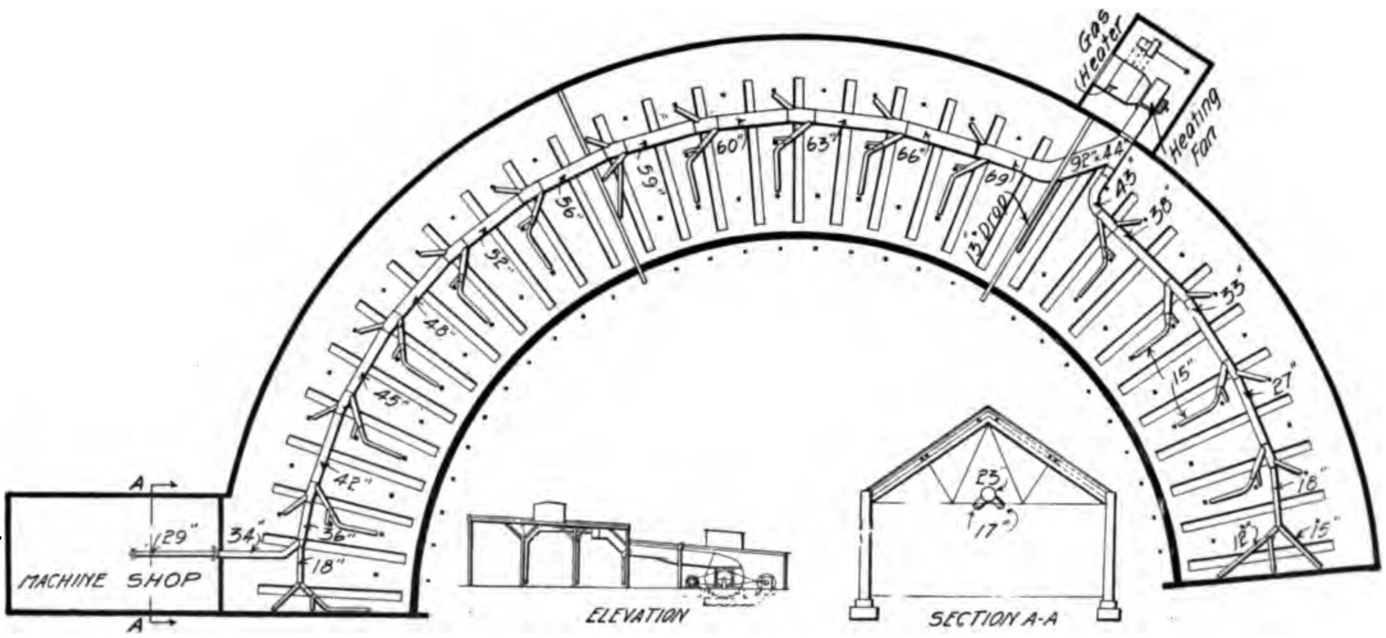
PLAN AND DETAILS OF STANDARD ROUNDHOUSE OF ERIE R. R.



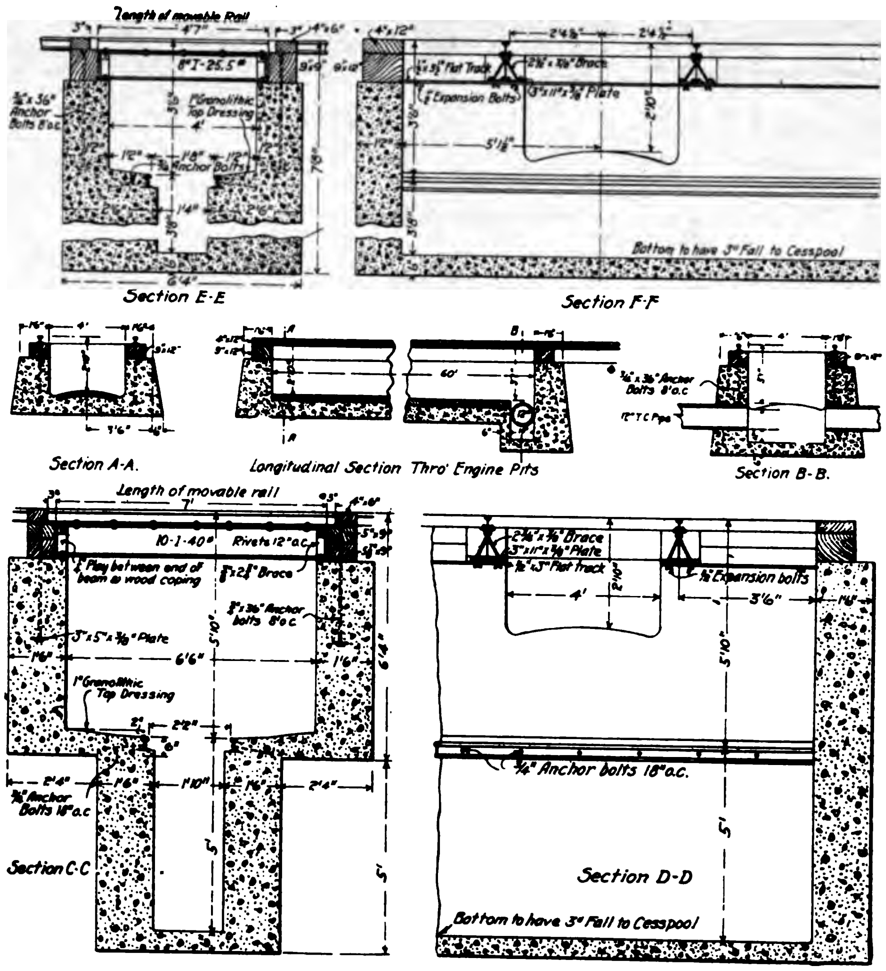
PLAN AND SECTION OF ROUNDHOUSE, SHOWING ARRANGEMENT OF HEATING APPARATUS AT MIDDLETOWN, N. Y., N. Y. O. & W. R. R.



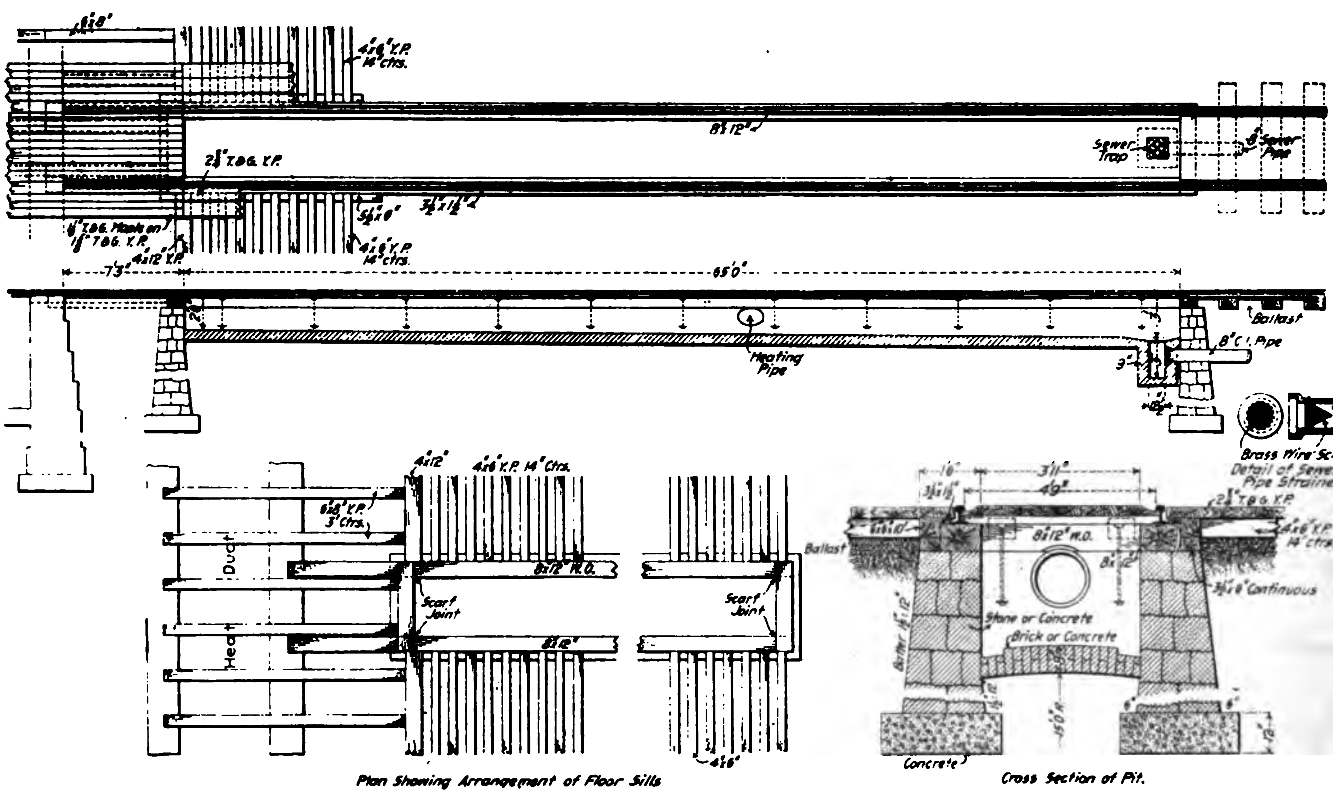
PLAN OF HEATING AND PIPE DUCTS FROM POWER HOUSE AND FAN HOUSE AT EAST ALTOONA LOCOMOTIVE TERMINAL, P. R. R.



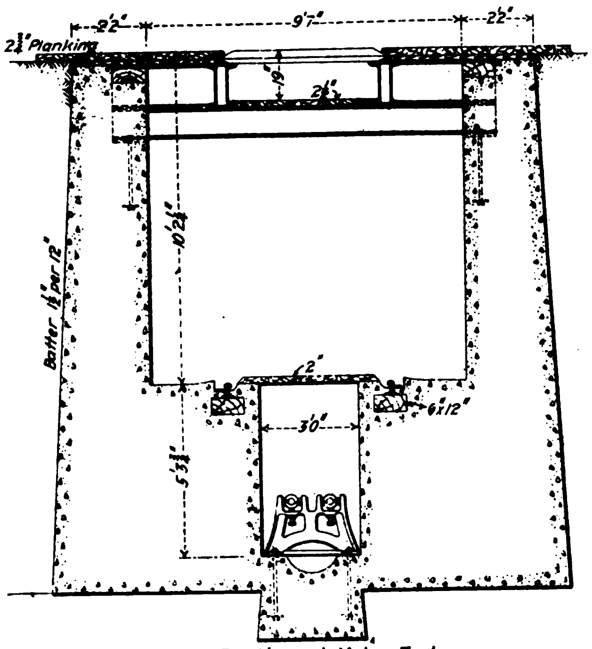
PLAN OF ROUNDHOUSE, SHOWING ARRANGEMENT OF HEATING APPARATUS AT PARSONS, KANS., M. K. & T. RY.



SECTION OF ENGINE PITS IN ROUNDHOUSE AT ATLANTA, GA., SOUTHERN RY.

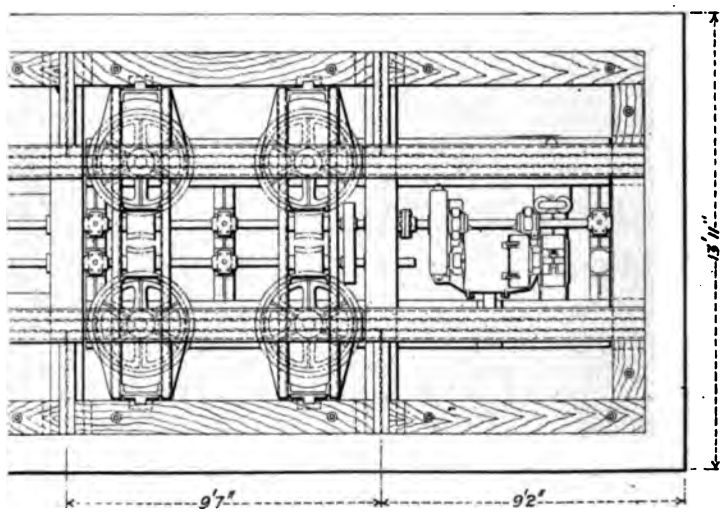


DETAILS OF ENGINE PITS AND ROUNDHOUSE FLOOR AT EAST ALTOONA, PA., P. R. R.

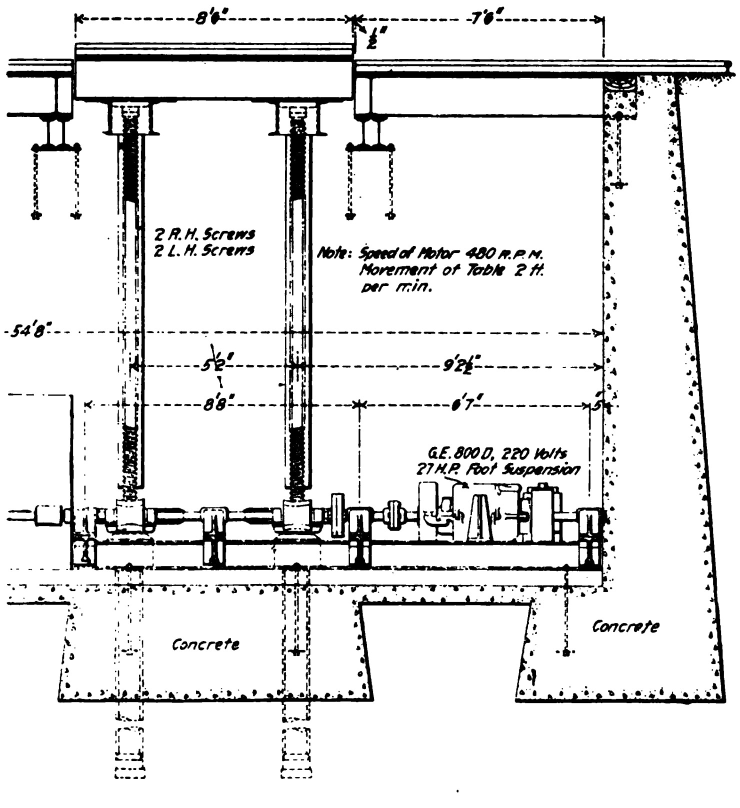


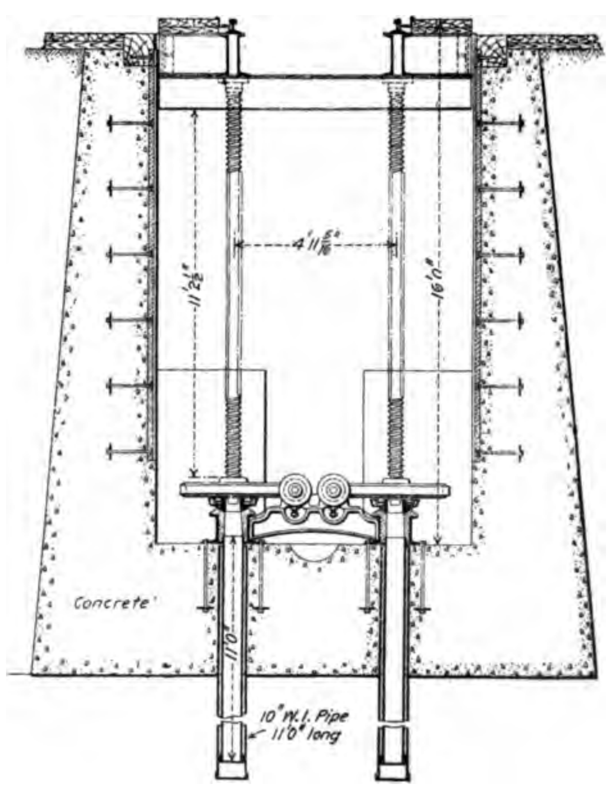
Section at Motor End.

CROSS SECTION THROUGH DROP PIT IN ROUNDHOUSE AT EAST ALTOONA, PA., P. R. R.

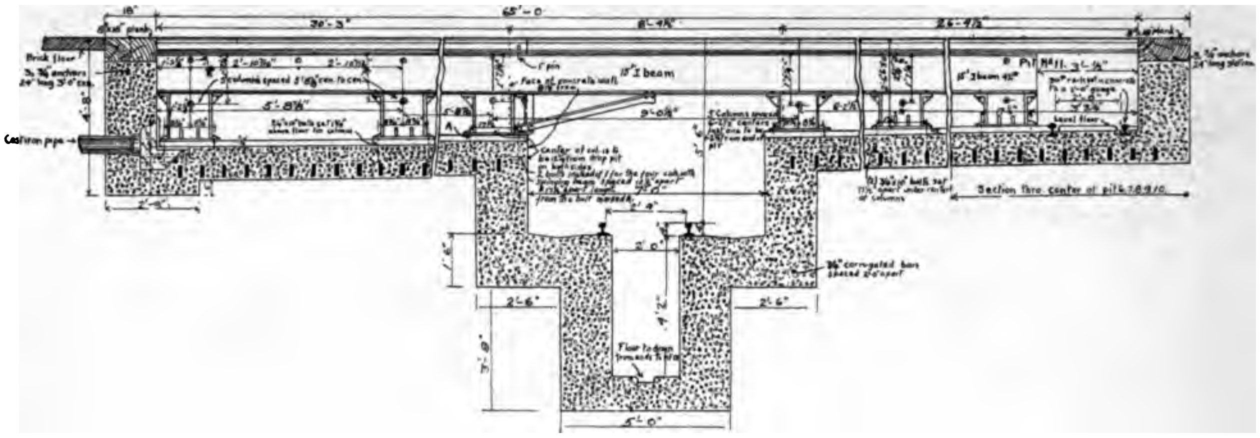


PLAN OF MACHINERY IN DROP PIT, EAST ALTOONA ROUNDHOUSE, P. R. R.

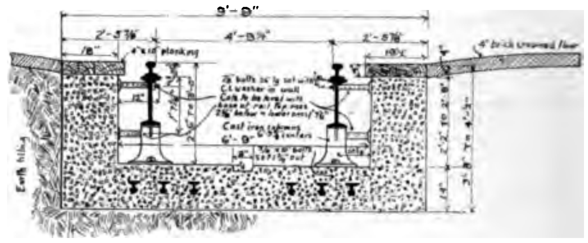




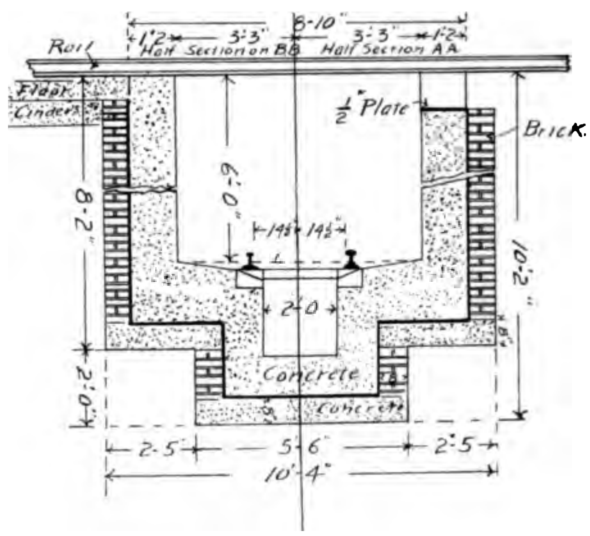
SECTIONS THROUGH DROP PITS AT EAST ALTOONA, PA., P. R. R.



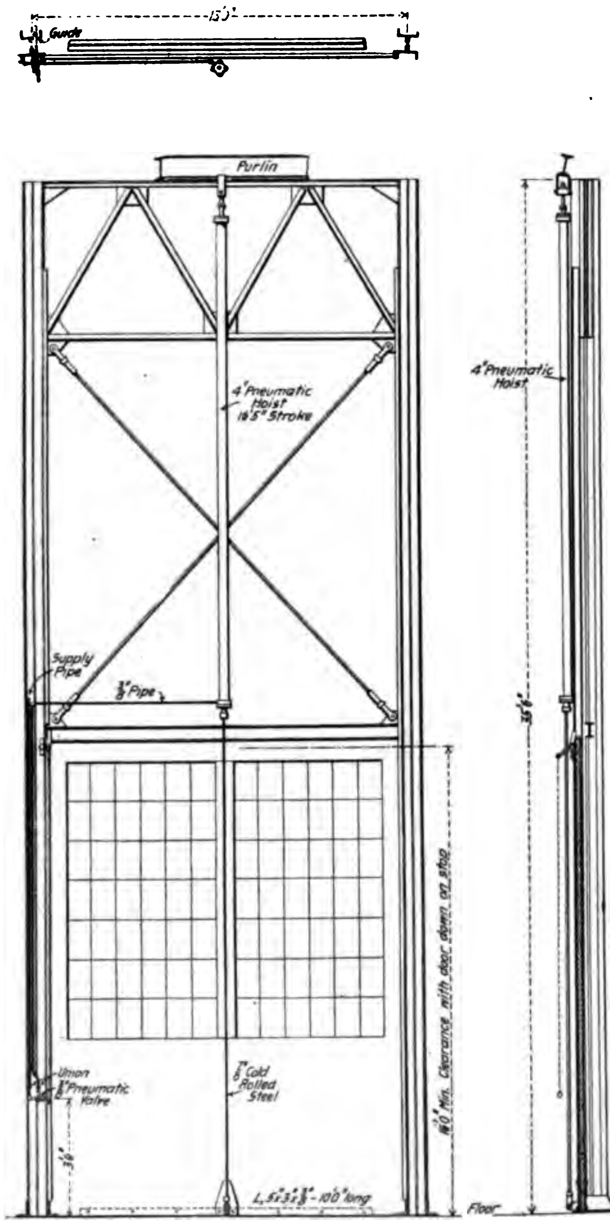
LONGITUDINAL SECTION OF PIT, INCLUDING SECTION TOWARD TURNTABLE, SECTION OF DRIVING WHEEL DROP PIT AND SECTION OF TRUCK DROP PIT IN ROUNDHOUSE AT PUEBLO, COLO., D. & R. G. R. R.



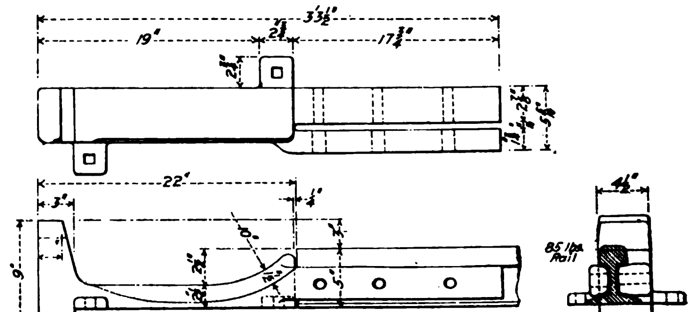
CROSS SECTION OF PIT IN ROUNDHOUSE AT PUEBLO, COLO., D. & R. G. R. R.



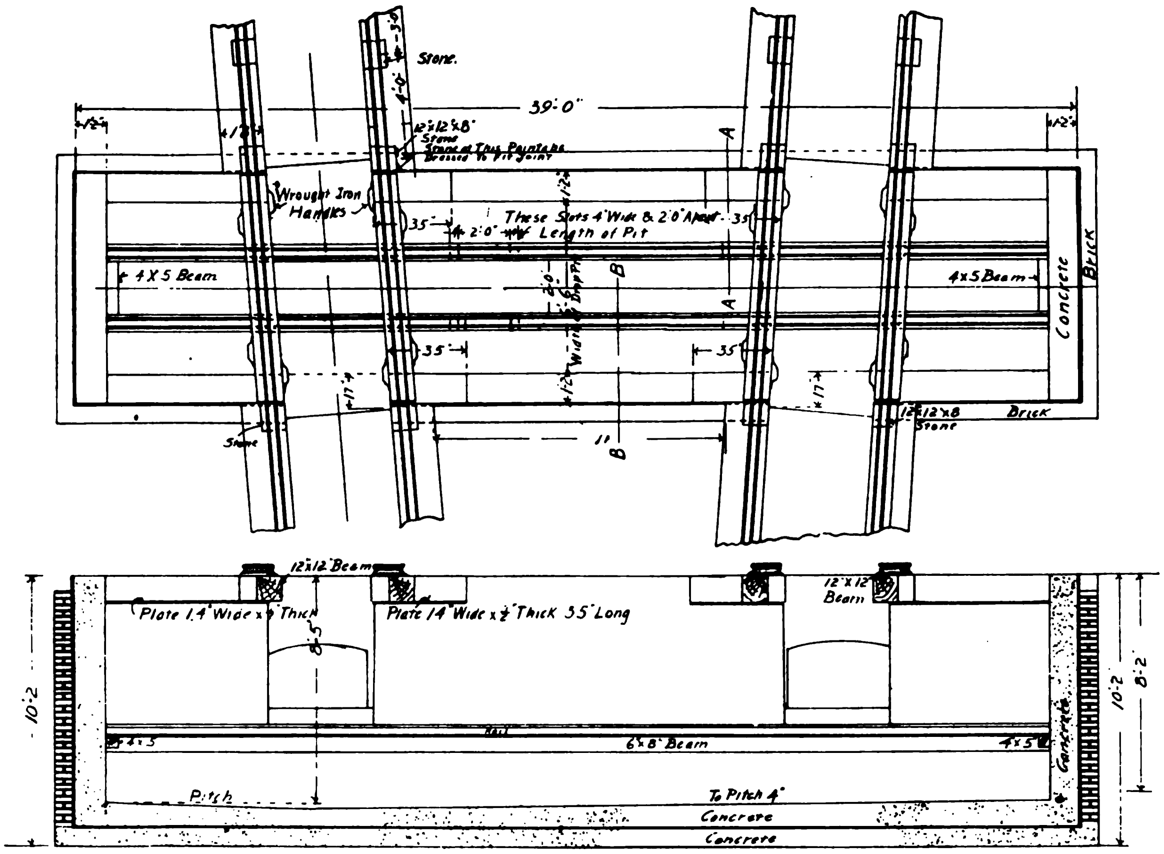
CROSS SECTION OF DROP PIT IN ROUNDHOUSE AT ONEONTA, N. Y., D. & H. R. R.



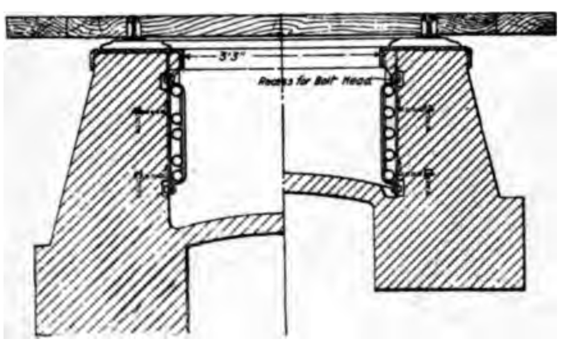
PNEUMATIC LIFTING DOOR IN ROUNDHOUSE AT EAST ALTOONA, PA., P. R. R.



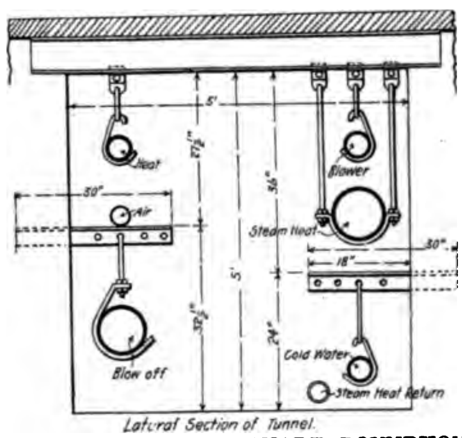
TRACK STOP USED IN ROUNDHOUSE AT EAST ALTOONA, PA., P. R. R.



PLAN AND LONGITUDINAL SECTION OF DROP PIT IN ROUNDHOUSE AT ONEONTA, N. Y., D. & H. R. R.



SECTION OF ENGINE PIT, SHOWING ARRANGEMENT OF STEAM HEATING PIPE ALONG SIDES OF PIT IN ROUNDHOUSE AT ELKHART, IND., L. S. & M. S. RY.



SECTION OF TUNNEL IN ELKHART ROUNDHOUSE, L. S. & M. S. RY.

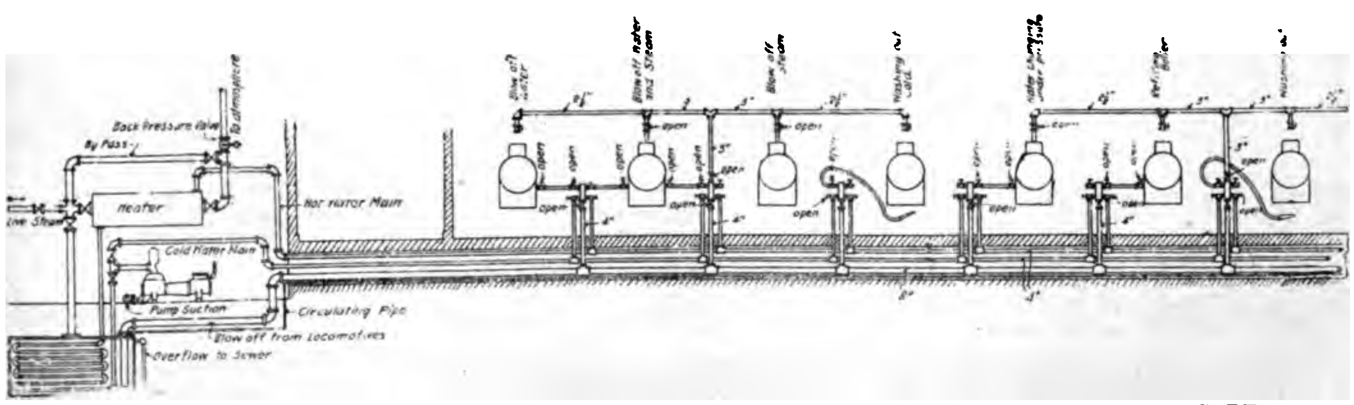
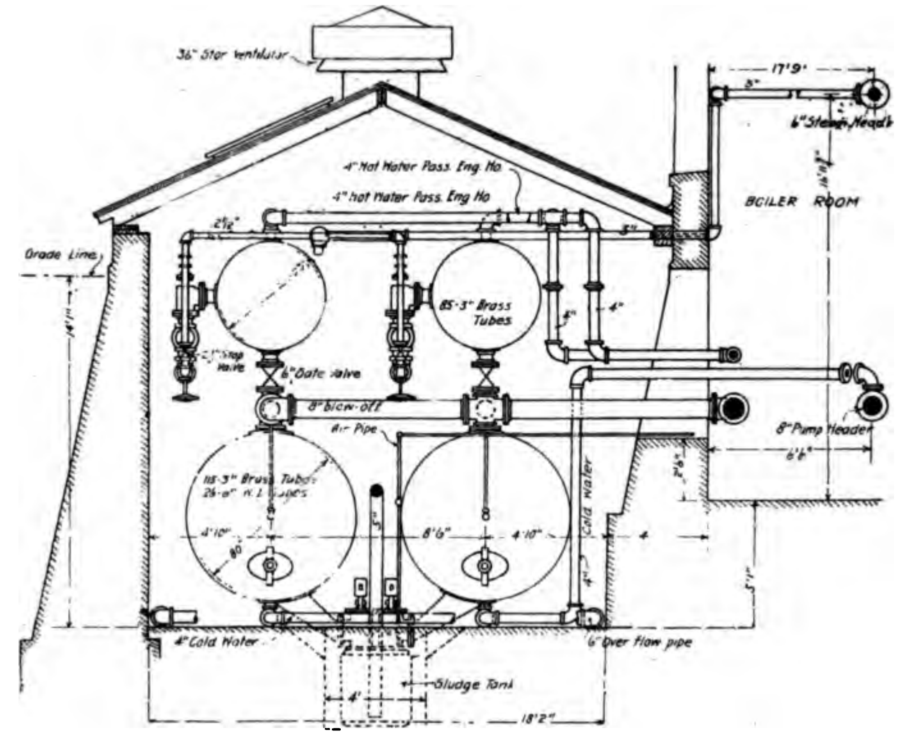
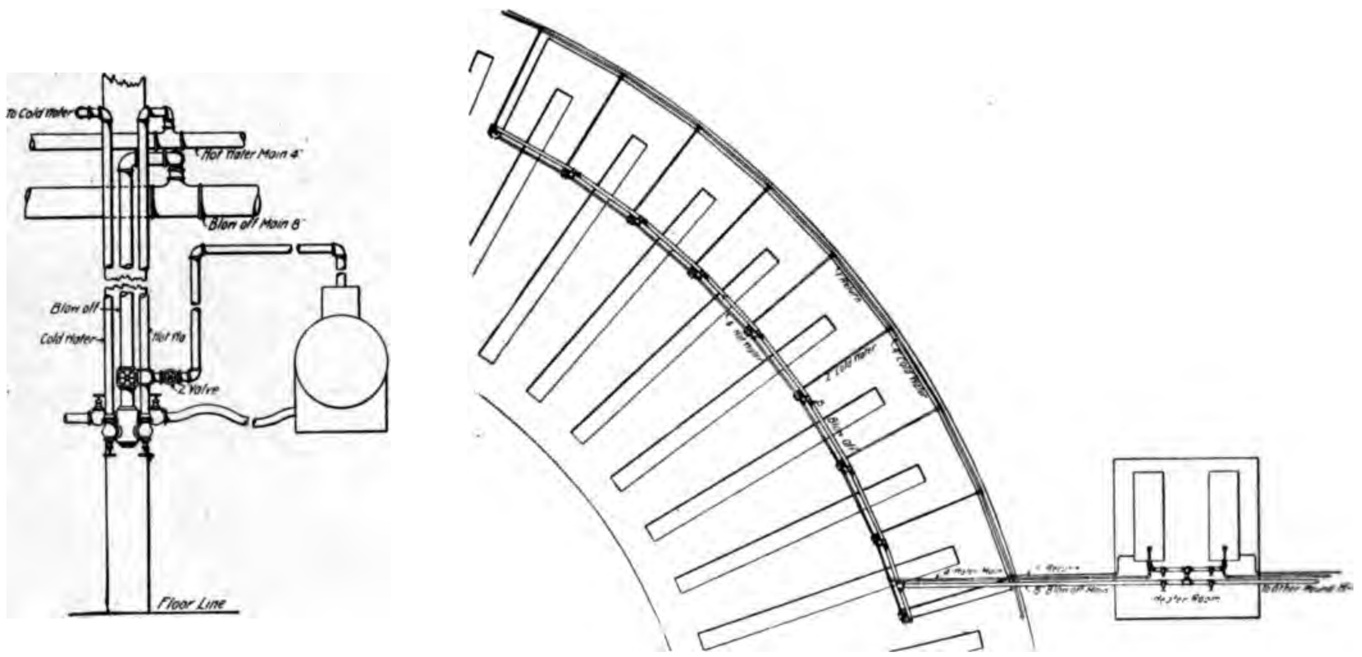


DIAGRAM ILLUSTRATING WASHING OUT SYSTEM IN ROUNDHOUSE AT ELKHART, IND., L. S. & M. S. RY.



PIPING CONNECTIONS AT HEATERS FOR BOILER WASHING SYSTEM IN ROUNDHOUSE AT ELKHART, IND., L. S. & M. S. RY.



ARRANGEMENT OF PIPING IN BOILER WASHING SYSTEM IN ROUNDHOUSE AT ELKHART, IND., L. S. & M. S. RY.

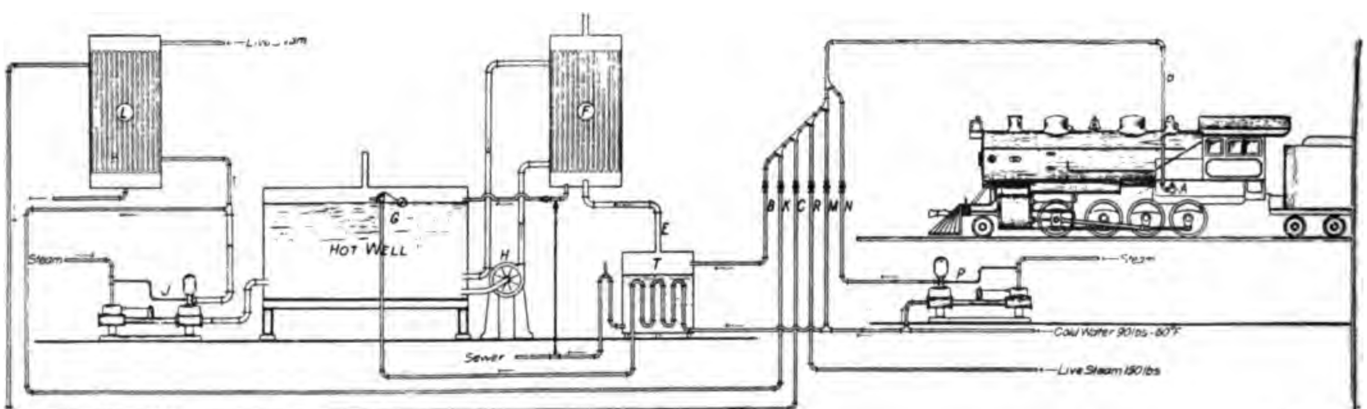
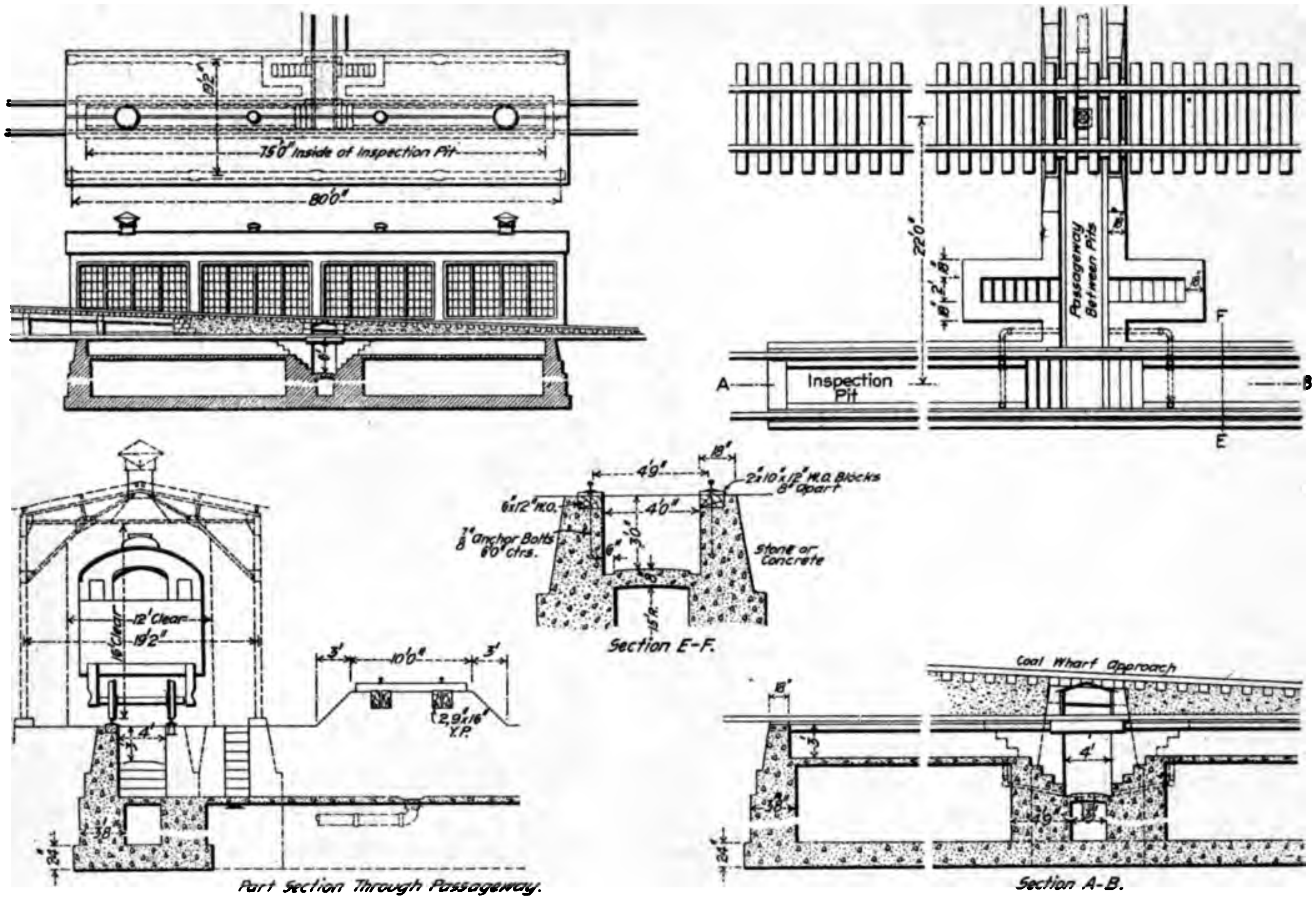
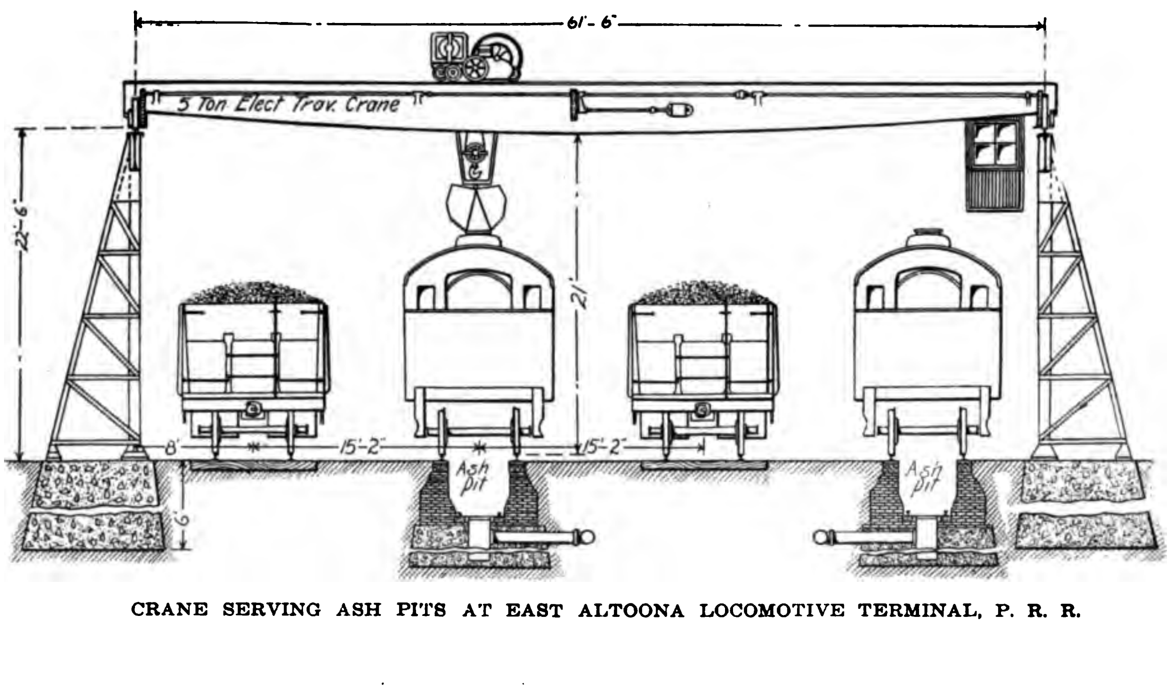


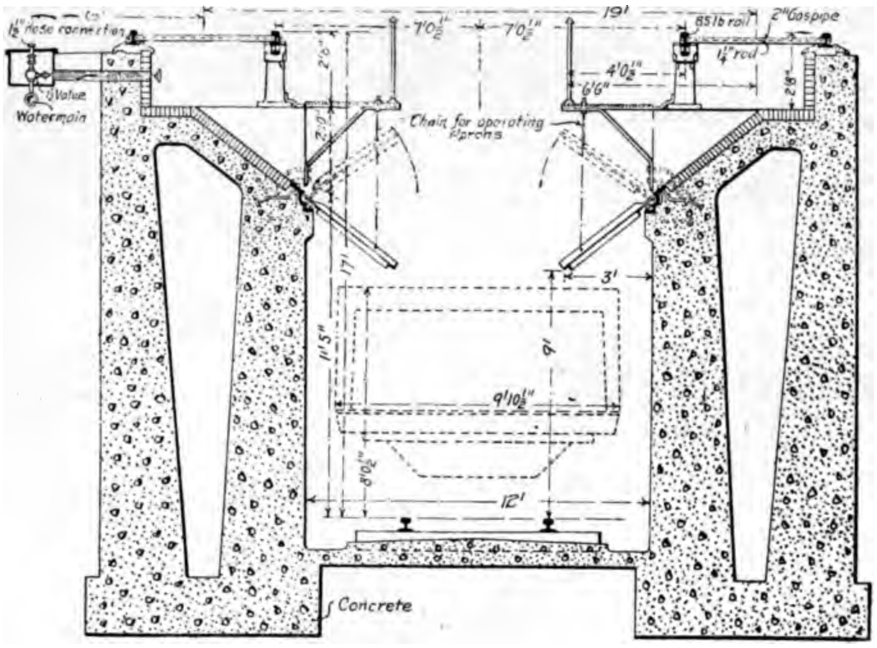
DIAGRAM ILLUSTRATING BOILER WASHING SYSTEM IN ROUNDHOUSE AT McKEES ROCKS, P. & L. E. R. R.



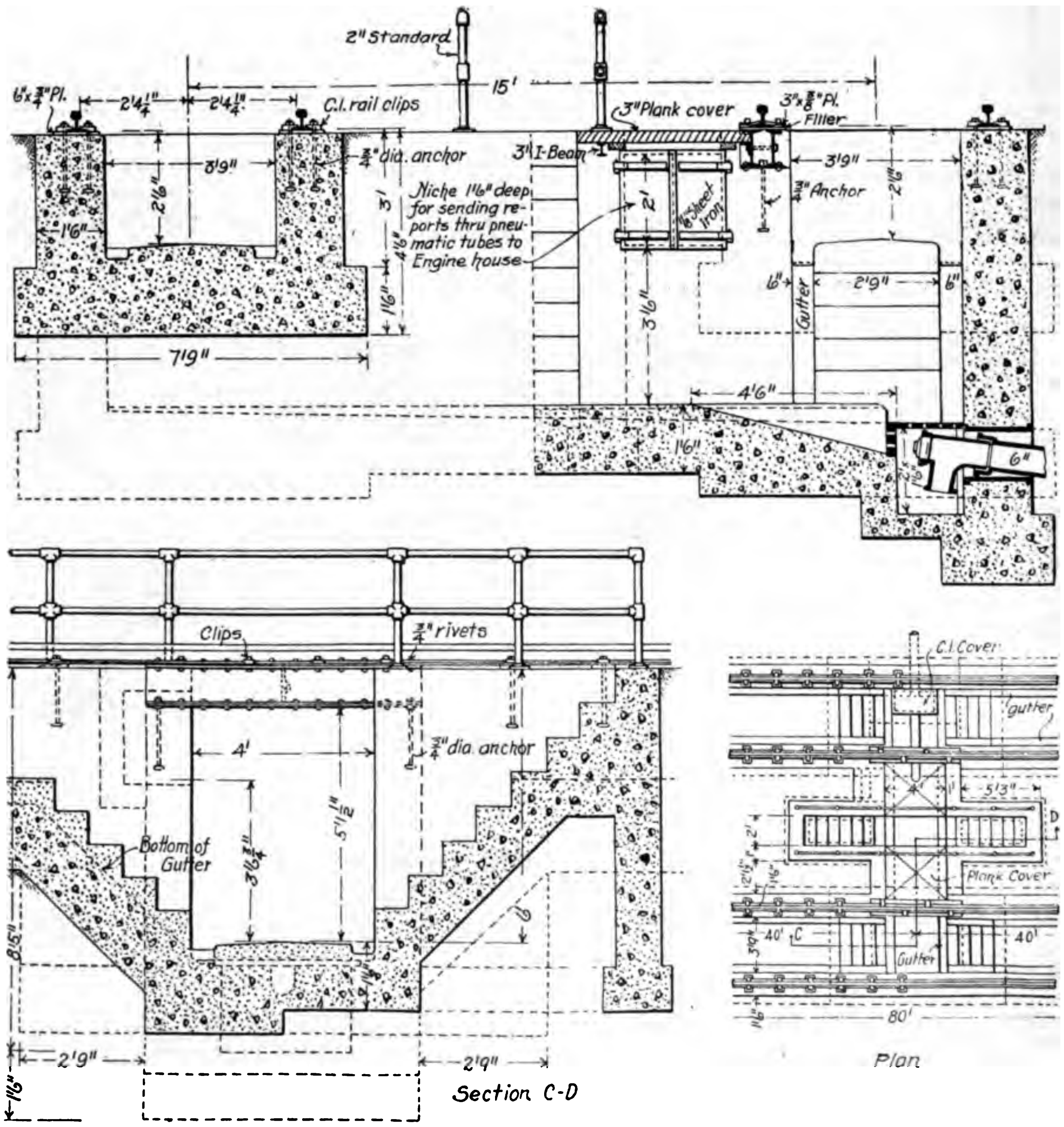
DETAILS OF INSPECTION PIT AT EAST ALTOONA LOCOMOTIVE TERMINAL, P. R. R.



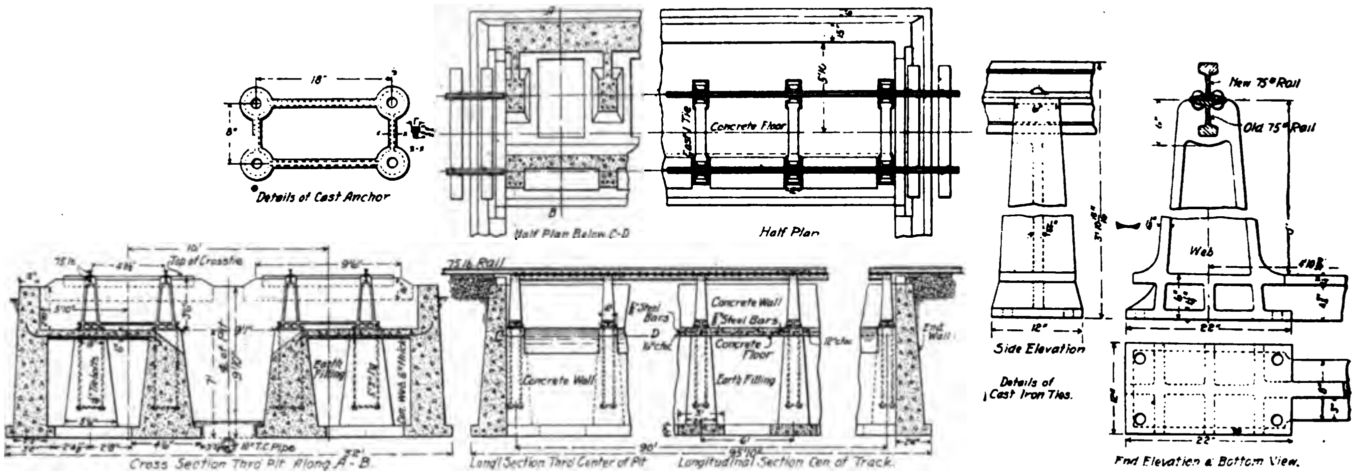
CRANE SERVING ASH PITS AT EAST ALTOONA LOCOMOTIVE TERMINAL, P. R. R.



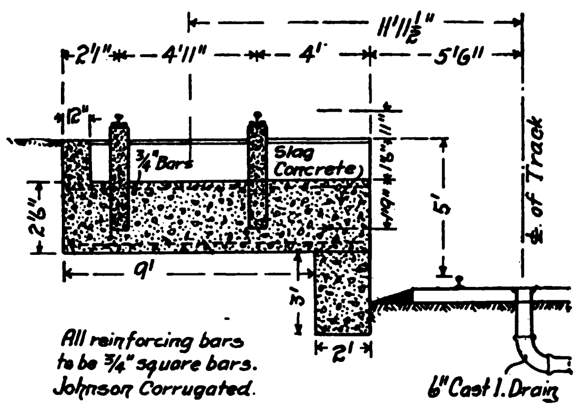
SECTION OF DOUBLE ASH PIT, B. & O. R. R.



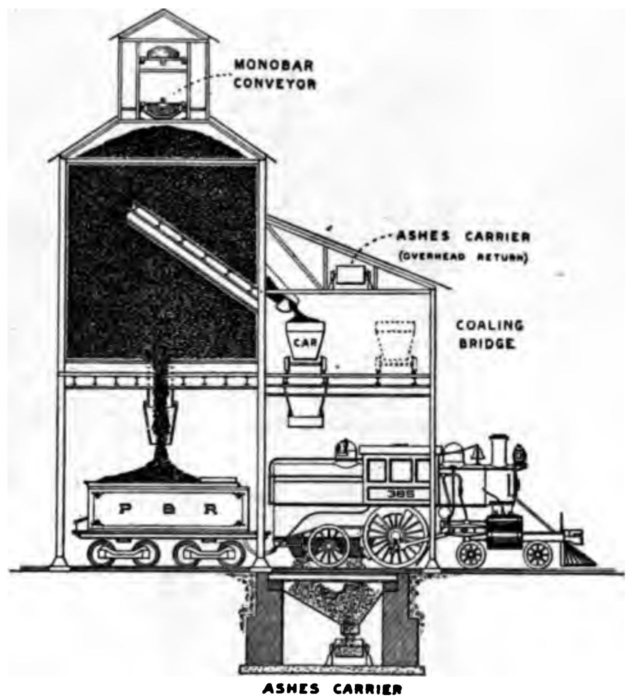
LOCOMOTIVE INSPECTION PIT, B. & O. LOCOMOTIVE TERMINALS.



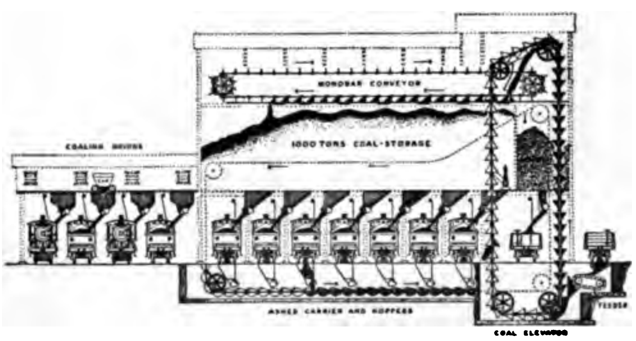
DETAILS OF DOUBLE CINDER PIT AND TRACK OF LOCOMOTIVE TERMINAL AT ATLANTA, GA., SOUTHERN RY.



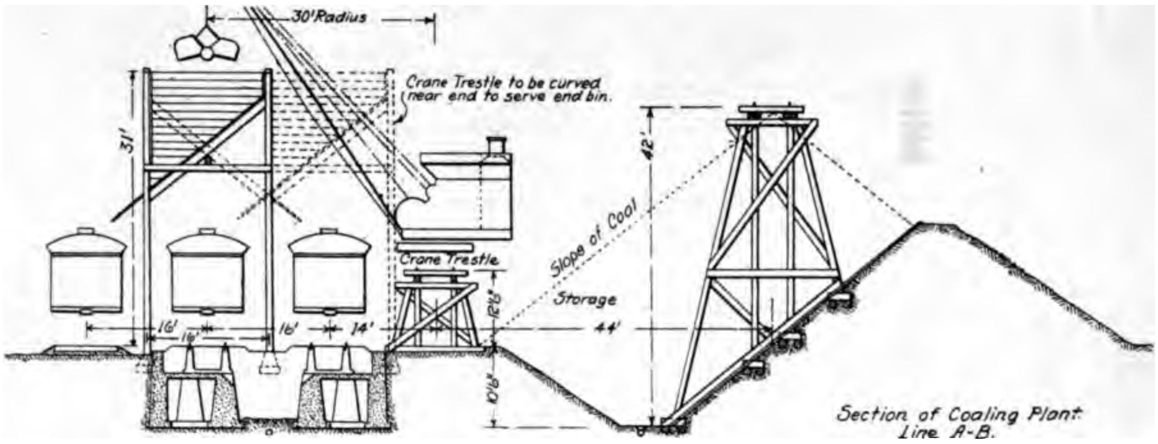
HALF SECTION OF CINDER PIT, EL PASO & SOUTH-WESTERN RY.



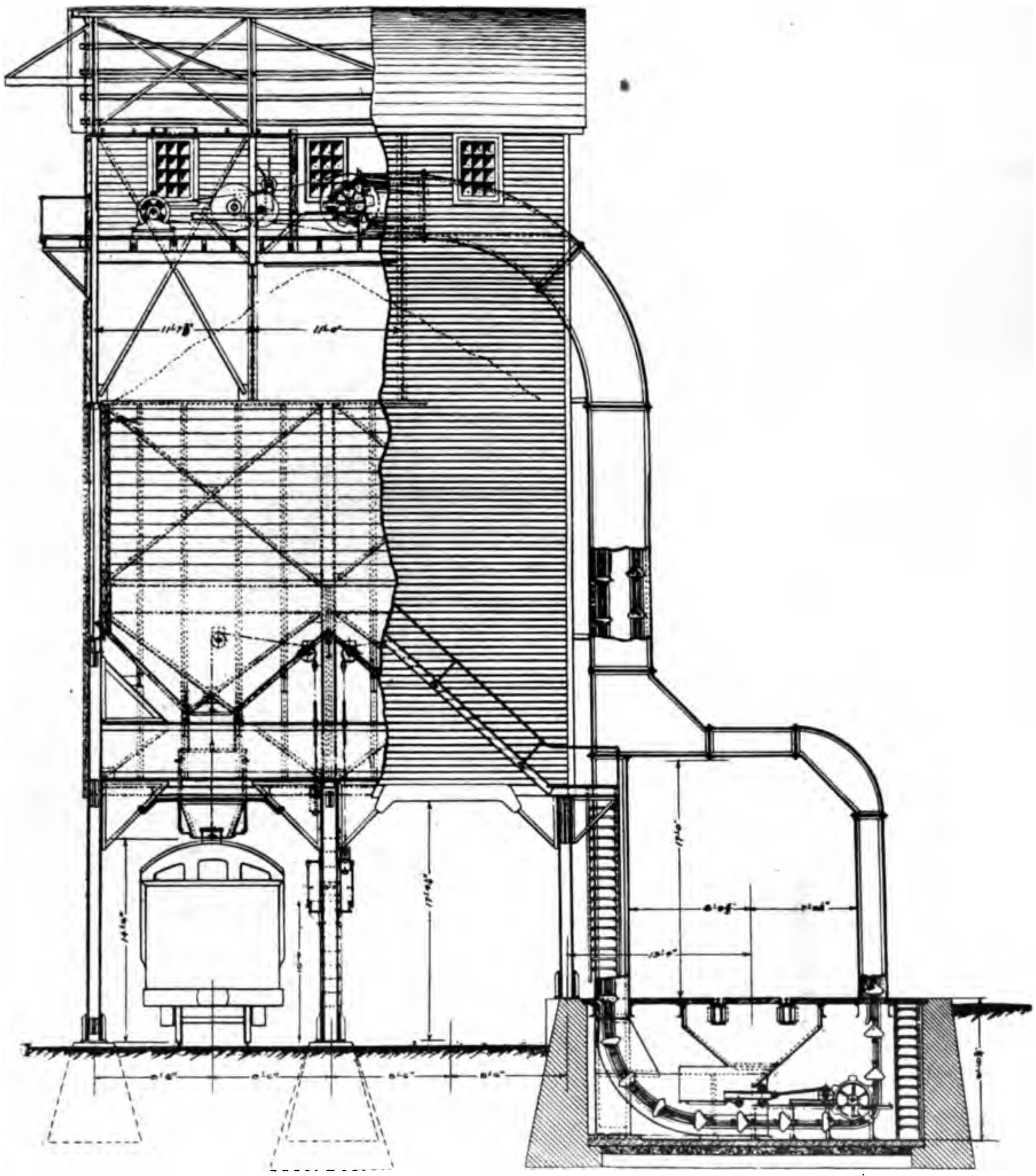
LOCOMOTIVE COALING AND CINDER STATION AT PHILA-DELPHIA, PA., P. & R. RY.



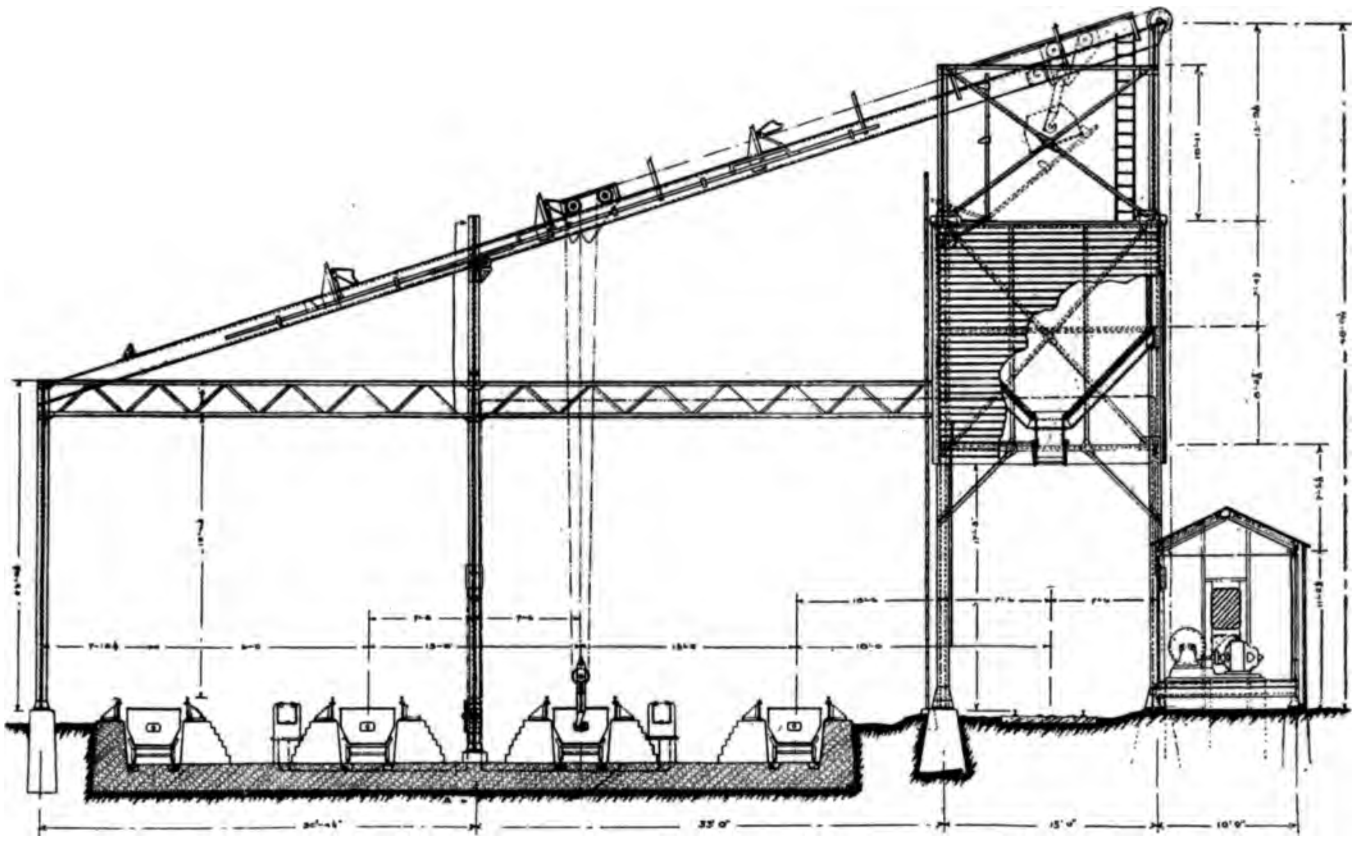
LOCOMOTIVE COALING AND CINDER STATION AT PHILA-DELPHIA, PA., P. & R. RY.



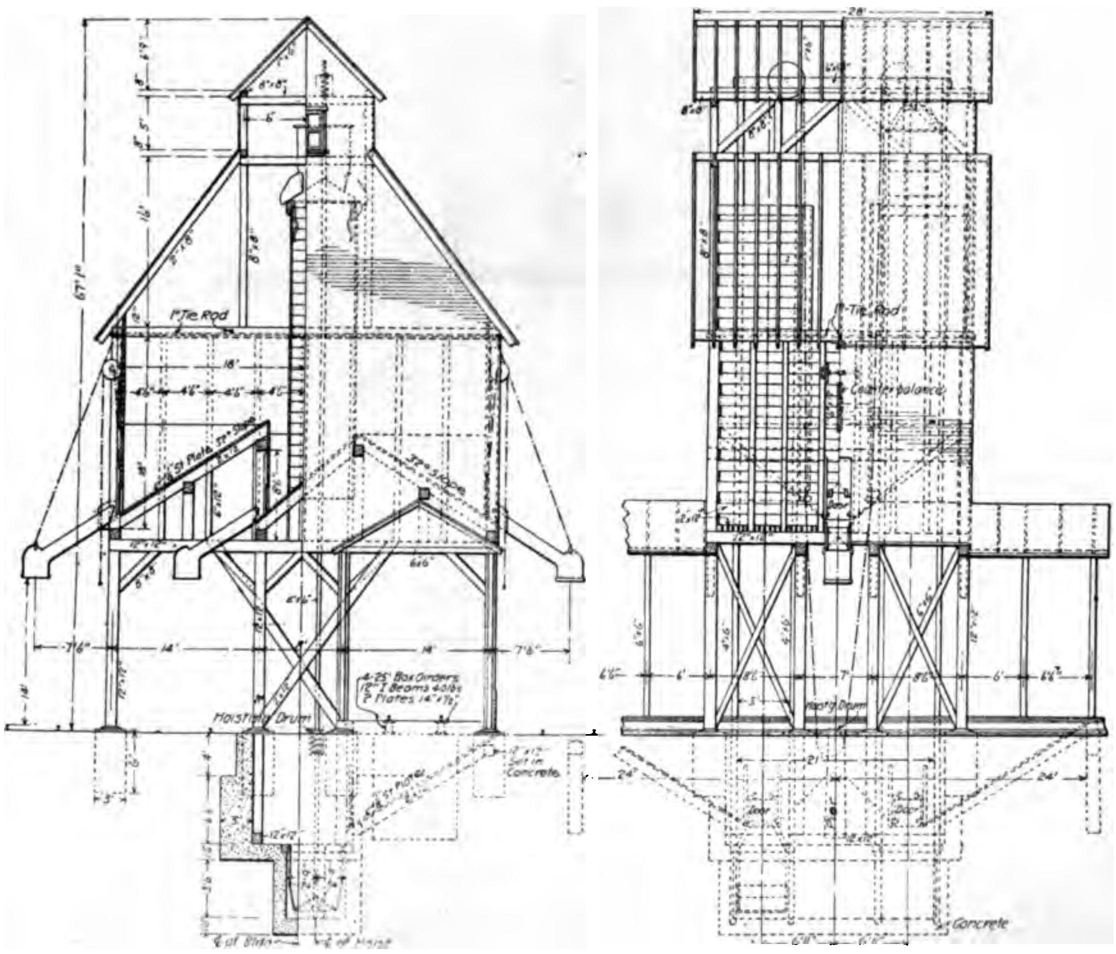
SECTION OF COALING PLANT AT INMAN YARDS, SOUTH ERN RY.



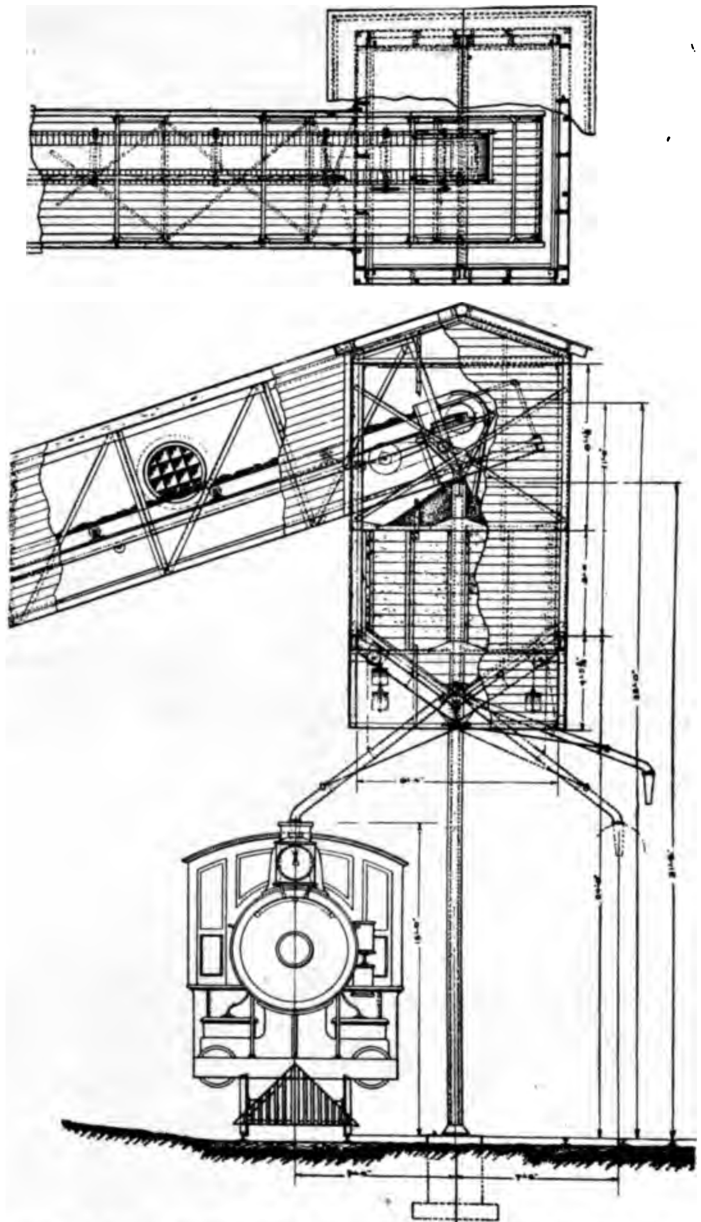
LOCOMOTIVE COALING STATION AT McKEES ROCKS, PA., P. & L. E. R. R.



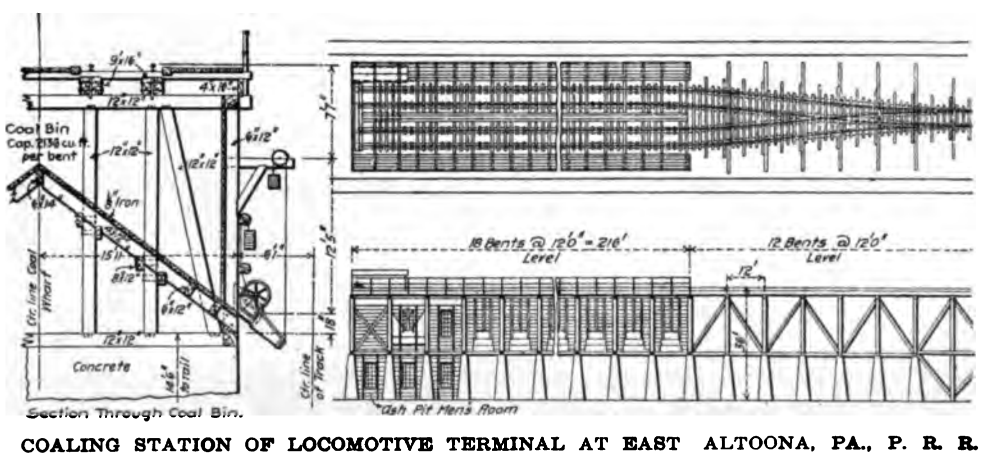
The Ash Handling Plant.
CROSS SECTION OF ASH HANDLING PLANT AT McKEES ROCKS, PA., P. & L. E. R. R.



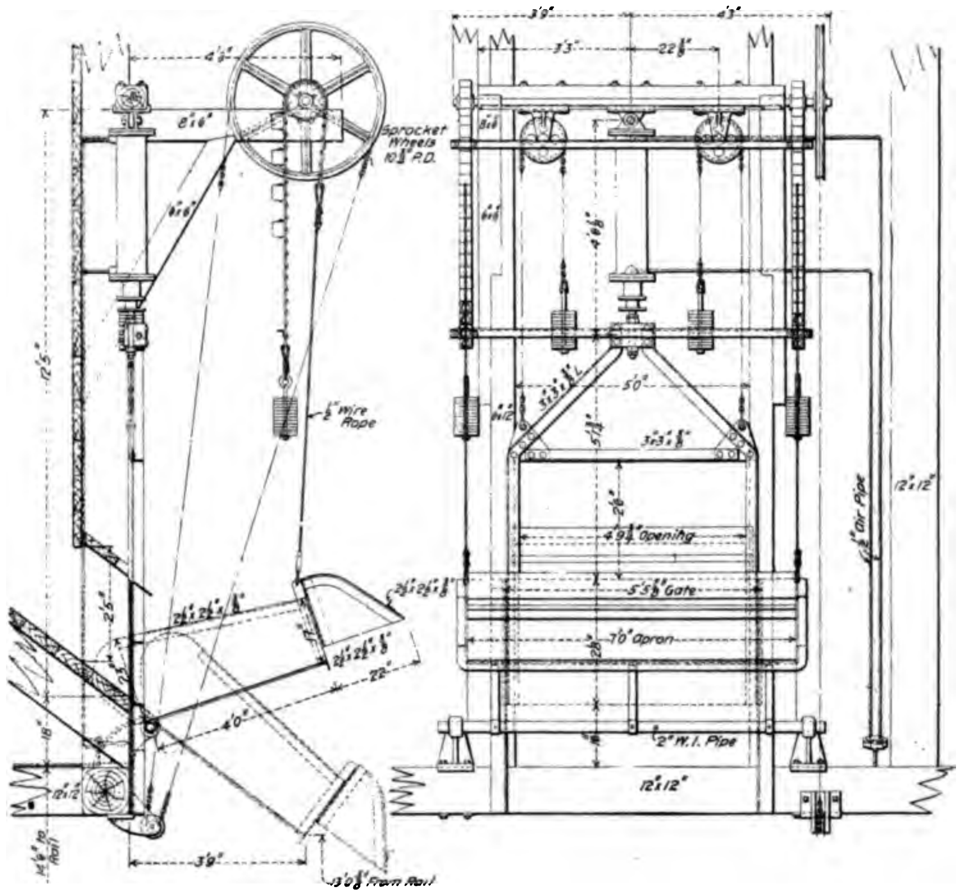
ELEVATIONS OF HOLMEN COALING STATION, PENNSYLVANIA LINES WEST.



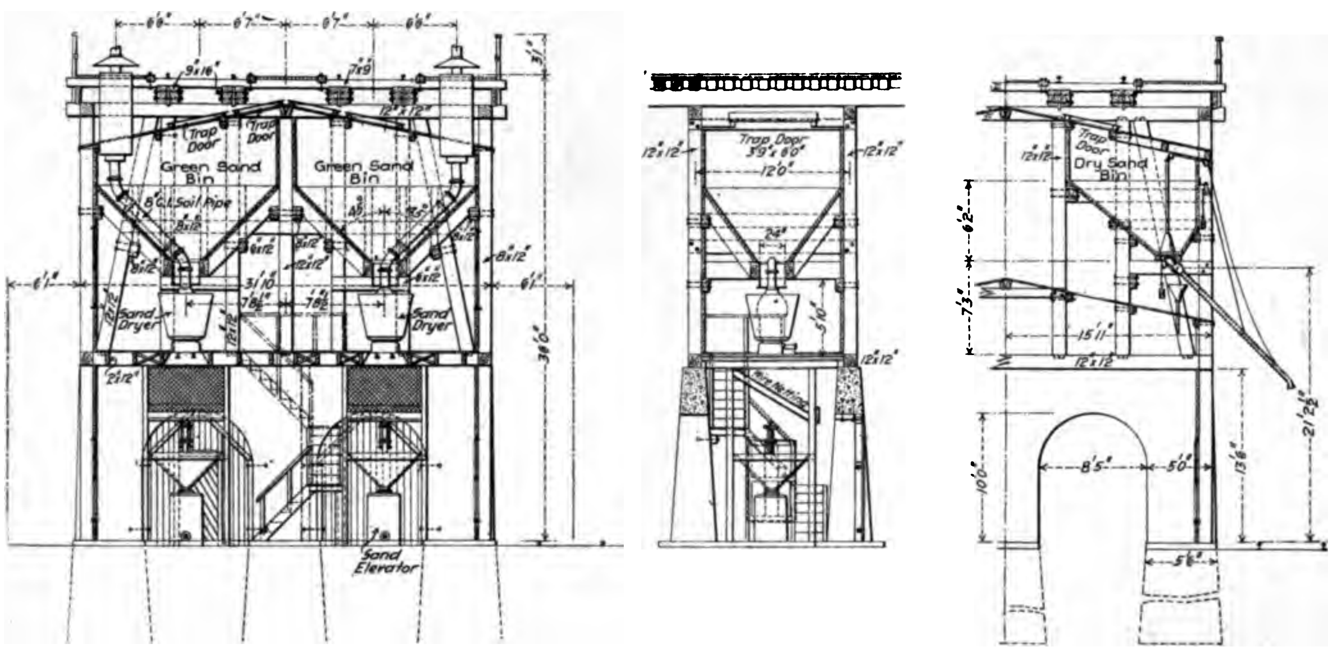
PARTIAL DETAILS OF SAND HANDLING STATION AT McKEES ROCKS, PA., P. & L. E. R. R



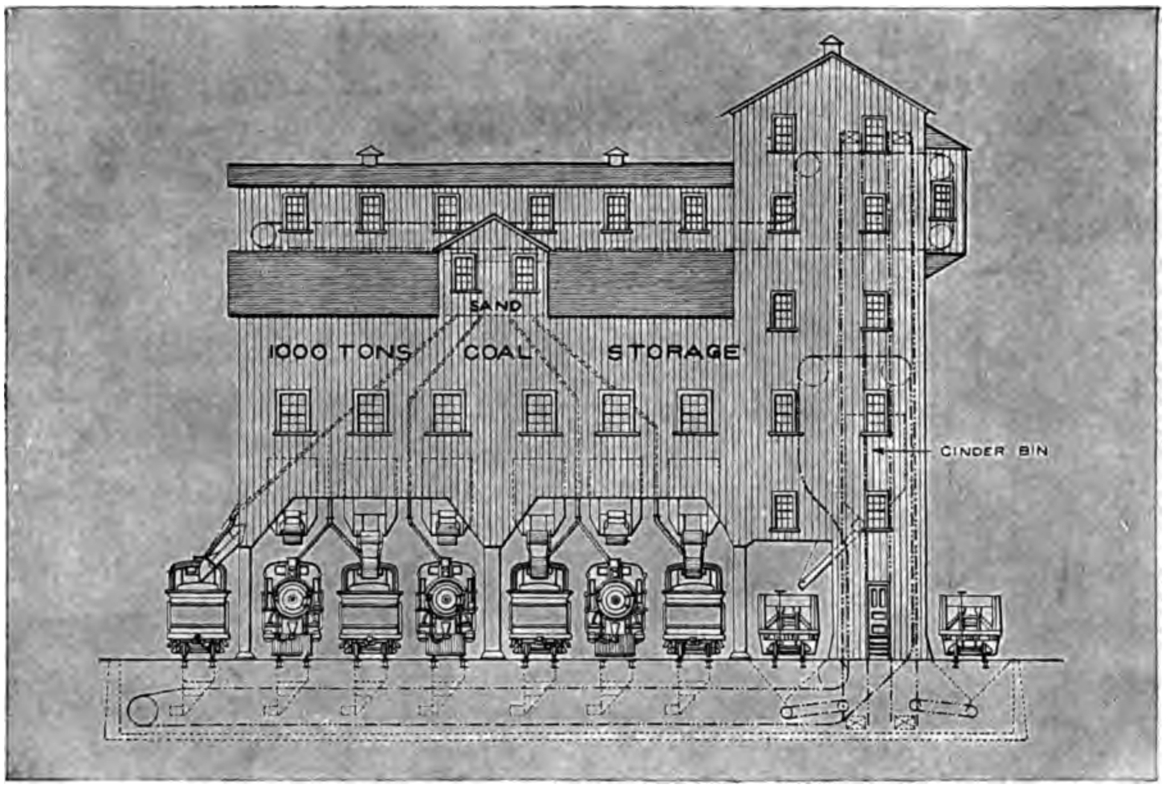
COALING STATION OF LOCOMOTIVE TERMINAL AT EAST ALTOONA, PA., P. R. R.



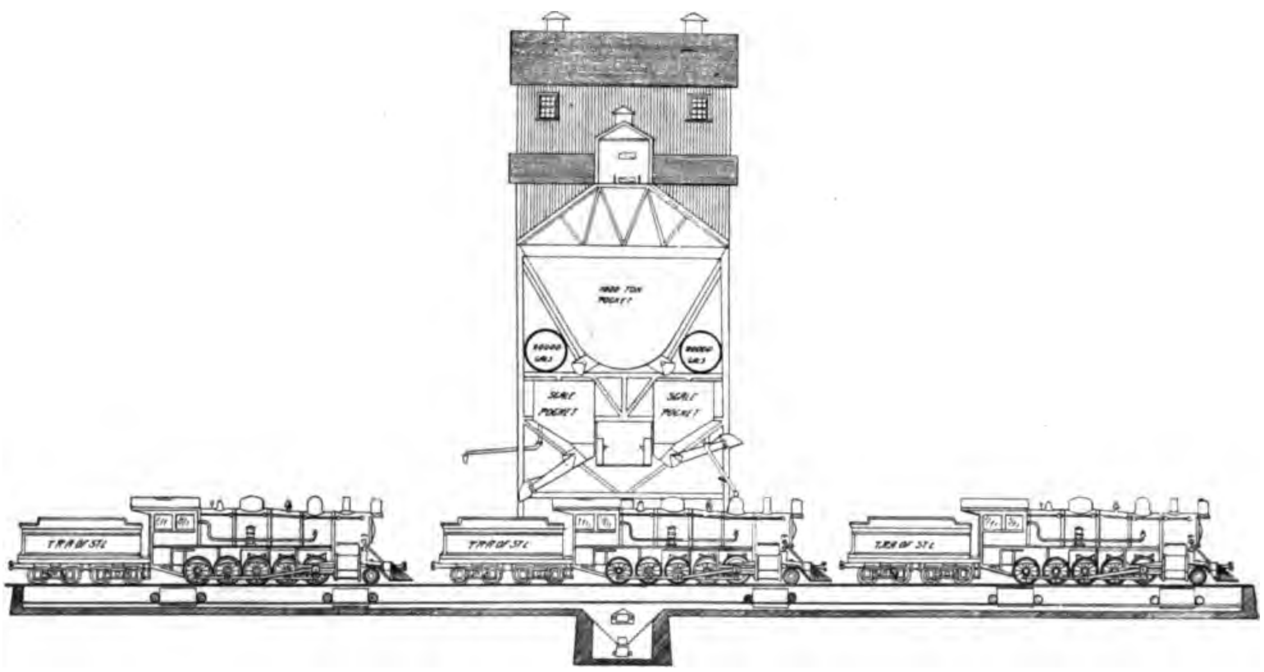
PNEUMATIC COAL CHUTE GATE ON LOCOMOTIVE COALING STATION OF LOCOMOTIVE TERMINAL AT EAST ALTOONA, PA., P. R. R.



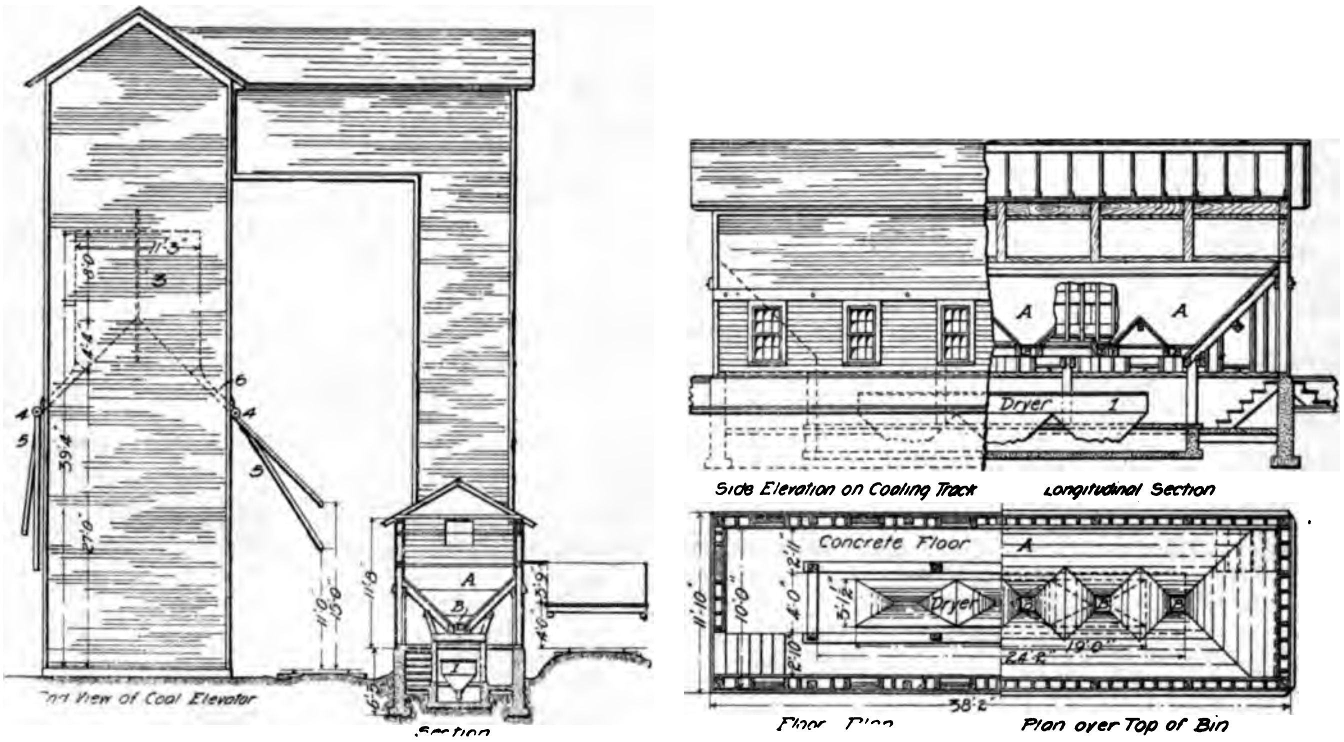
SAND DRYING AND STORAGE PLANT OF LOCOMOTIVE TERMINAL AT EAST ALTOONA, PA., P. R. R.



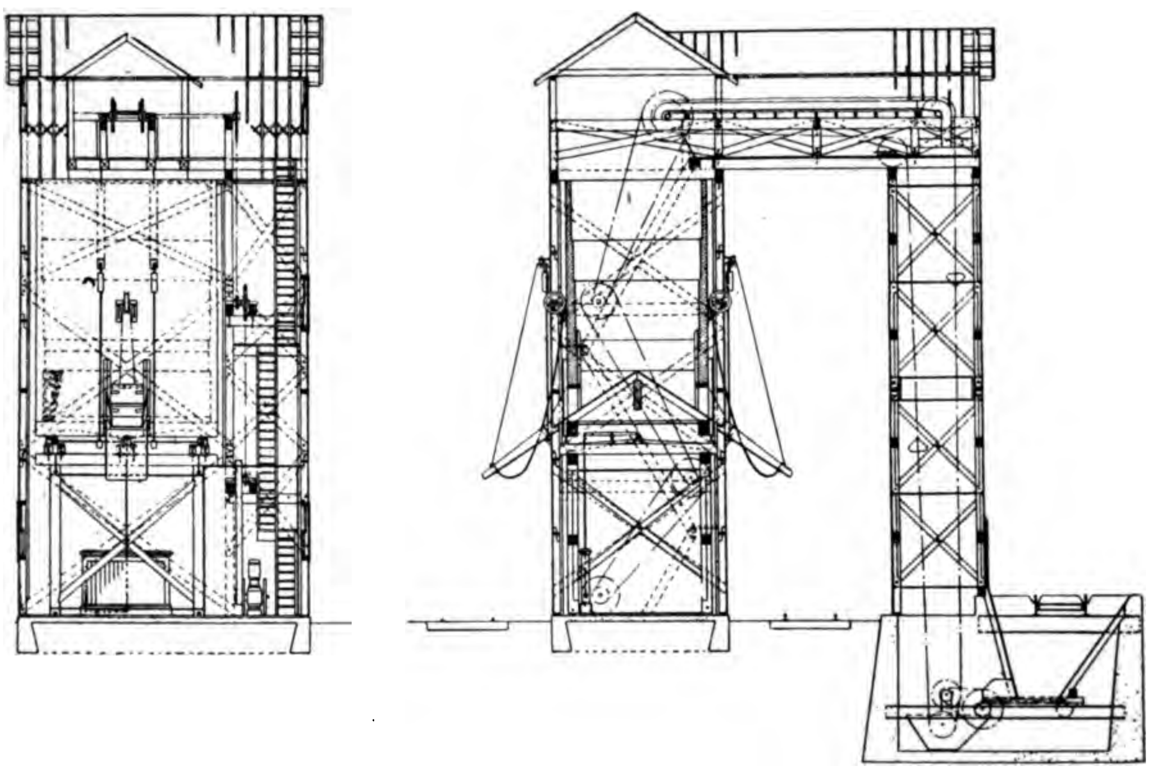
SIDE ELEVATION OF COALING STATION AT ST. LOUIS, MO., T. R. R. ASSN. OF ST. L.



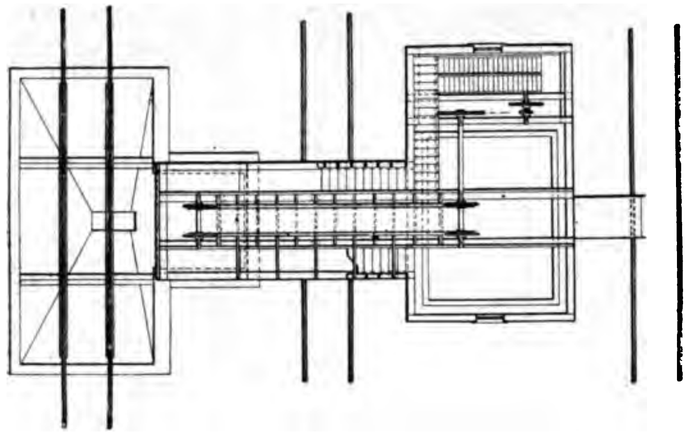
END ELEVATION OF COALING STATION AT ST. LOUIS, MO., T. R. R. ASSN. OF ST. L.



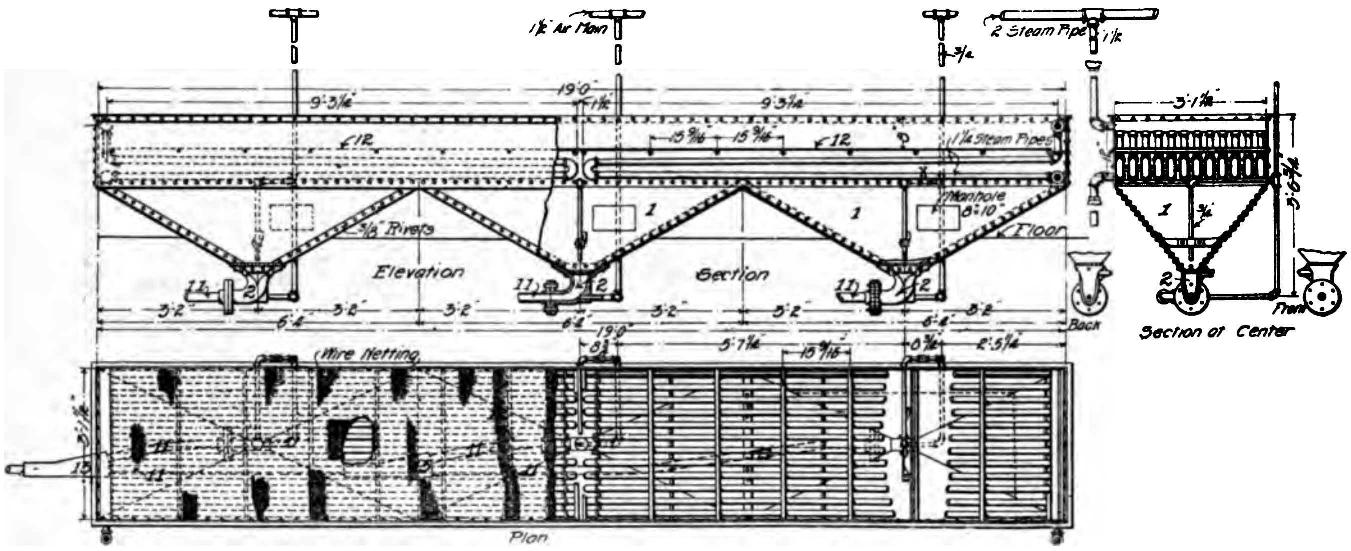
COALING STATION AND SAND DRYING PLANT OF PERE MARQUETTE R. R.



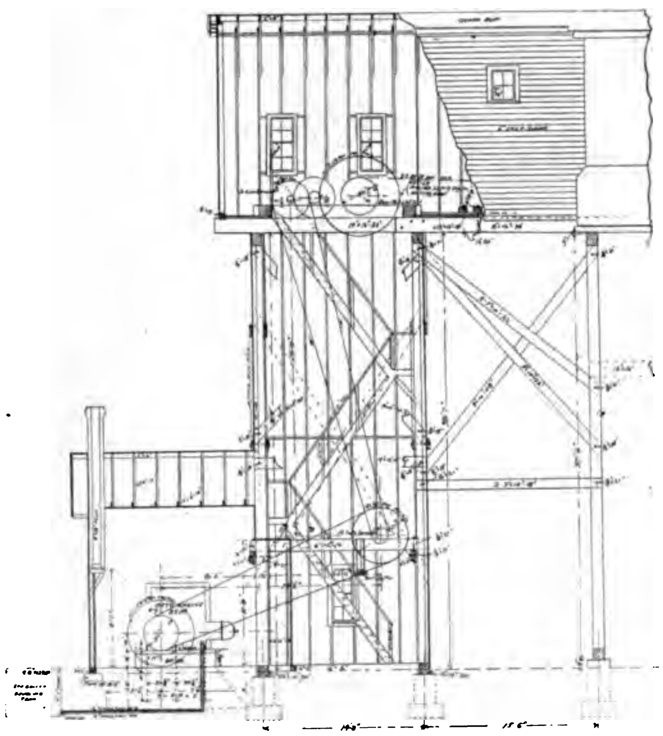
SECTION OF COALING STATION OF PERE MARQUETTE R. R.



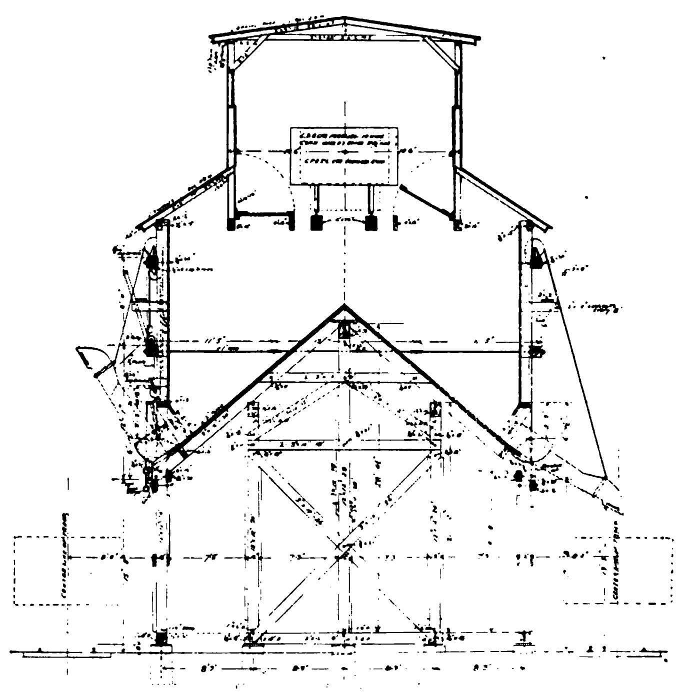
PLAN OF COALING STATION, PERE MARQUETTE R. R.



SAND DRYING PLANT OF PERE MARQUETTE R. R.



ARRANGEMENT OF MECHANISM FOR ELEVATING CARS AT COALING STATION, C. & N. W. RY.



SECTION OF DOUBLE CHUTE COALING STATION, C. & N. W. RY.

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Engineering News	Eng. News
Engineering Record	Eng. Rec.
Locomotive Engineering	Loc. Eng.
Railroad Gazette	R. R. Gaz.
Railway Age	Ry. Age.
Railway Engineering and Maintenance of Way	Ry. Eng.
Railway Master Mechanic	Ry. M. M.
Railway and Engineering Review	Ry. Rev.

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